L Number	Hits	Search Text	DB	Time stamp
1	31	(US-3686914-$ or US-6276040-$ or US-6220804-$ or US-5340251-$ or US-3878599-$ or US-3469613-$ or US-3253631-$ or US-2486769-$ or US-4690599-$ or US-3926236-$ or US-3999659-$ or US-3878598-$ or US-2206740-$ or US-2096623-$ or US-6325584-$ or US-5333980-$ or US-4221041-$ or US-4130922-$ or US-4039099-$ or US-2465534-$ or US-0371884-$ or US-6108890-$ or US-6581259-$ or US-6042313-$ or US-4826372-$ or US-3789728-$).did. or (US-20030123947-$).did. or (EP-28019-$).did. or (DE-3447006-$ or GB-2341654-$ or US-4204308-$).did.	USPAT; US-PGPUB; EPO; DERWENT	2004/01/30 19:28
2	2	("6213699").PN.	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 19:28
3	25	("2538623" | "3288016" | "3292482" | "3298725" | "3377907" | "3390601" | "3515419" | "3702088" | "4046053" | "4089249" | "4355934" | "4405273" | "4627775" | "4639174" | "4781500" | "4789283" | "4846611" | "4863325" | "4904133" | "4969785" | "5054977" | "5102274" | "5286151" | "5503510" | "5810530").PN.	USPAT	2004/01/30 19:28
-	52	"0028019"	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 14:38
-	0	80106504.6	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/28 20:01
-	0	"801065046"	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/28 20:01
-	0	"0028019A1"	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/28 20:02
-	0	EP000028019	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/28 20:04
-	0	EP0028019A1	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/28 20:03
-	0	0028019A1	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/28 20:03
-	0	000028019A1	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/28 20:03
-	0	"000028019"	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/28 20:04
-	0	("EP28019").PN.	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/28 20:04

-	1	("0028019").PN.	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/28 20:05
-	31	danino.in.	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/28 20:06
-	1	("0028019").PN.	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/28 20:06
-	2	("3686914").PN.	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/28 20:08
-	0	("29509439").PN.	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/28 20:09
-	0	("DE29509439").PN.	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/28 20:22
-	125724	bolt and (body or shank or shaft) and (head or cap)	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/28 20:23
-	7224	(bolt and (body or shank or shaft) and (head or cap)) and (head or cap) with hollow	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 18:55
-	0	DE003447006	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/29 14:33
-	0	("DE3447006").PN.	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/29 14:33
-	3	("3447006").PN.	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 15:13
-	1	09/921299	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/29 18:47
-	21	"3469613"	USPAT	2004/01/30 14:38
-	9	(("3469613") or ("4690699") or ("3253631") or ("3962236") or ("3878599") or ("6276040") or ("5340251") or ("6220804") or ("2486769")).PN.	USPAT	2004/01/30 14:41
-	9	(("3469613") or ("4690599") or ("3253631") or ("3962236") or ("3878599") or ("6276040") or ("5340251") or ("6220804") or ("2486769")).PN.	USPAT	2004/01/30 14:42
-	9	(("3469613") or ("4690599") or ("3253631") or ("3926236") or ("3878599") or ("6276040") or ("5340251") or ("6220804") or ("2486769")).PN.	USPAT	2004/01/30 14:43
-	4	(("3999659") or ("3878598") or ("2206740") or ("2096623")).PN.	USPAT	2004/01/30 14:44
-	0	WO000172449	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 14:44

-	0	"000172449"	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 14:44
-	1	("0172449").PN.	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 14:44
-	0	("WO172449").PN.	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 14:44
-	2	("5564857").PN.	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 15:19
-	1194	(411/179,180,181,183,107,501,502,503).CCLS.	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 15:19
-	2474	(29/432.2,432.1,432,512).CCLS.	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 15:20
-	0	("017or18").PN.	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 15:20
-	3513	((411/179,180,181,183,107,501,502,503).CCLS or ((29/432.2,432.1,432,512).CCLS.)	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 16:35
-	0	("(fastenerorrivelorbolt)and(cavityorhollow)with(headorcap)").PN.	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 15:21
-	24297	(fastener or rivet or bolt) and (cavity or hollow) with (head or cap)	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 16:39
-	9617	((fastener or rivet or bolt) and (cavity or hollow) with (head or cap)) and (cavity or hollow) near3 (head or cap)	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 18:56
-	1670	(((fastener or rivet or bolt) and (cavity or hollow) with (head or cap)) and (cavity or hollow) near3 (head or cap)) and (sheet adj metal or panel)	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 15:55
-	31	((((fastener or rivet or bolt) and (cavity or hollow) with (head or cap)) and (cavity or hollow) near3 (head or cap)) and (sheet adj metal or panel)) and (((411/179,180,181,183,107,501,502,503).CCLS.)	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 16:07
-	6	[illegible] "4146118" | "4221041" | "4430034").PN.	USPAT	2004/01/30 15:57
-	15	4430034.URPN.	USPAT	2004/01/30 15:57
-	109	self adj piercing adj rivet	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 18:55
-	4	"6108890"	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 16:18
-	1357	(((411/179,180,181,183,107,501,502,503).CCLS. or ((29/432.2,432.1,432,512).CCLS.)) and @PD<19620606	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 16:33

-	3513	((411/179,180,181,183,107,501,502,503).CCLS. or ((29/432.2,432.1,432,512).CCLS.)	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 16:36
-	895	((fastener or rivet or bolt) and (cavity or hollow) with (head or cap)) and (head or cap) same (body or shaft) same diameter same (equal or "same")	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 16:41
-	237	(((fastener or rivet or bolt) and (cavity or hollow) with (head or cap)) and (head or cap) same (body or shaft) same diameter same (equal or "same")) and (head or cap) with (body or shaft) with diameter with (equal or "same")	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 16:41
-	0	20030226983.URPN.	USPAT	2004/01/30 16:41
-	23	(US-3686914-$ or US-6276040-$ or US-6220804-$ or US-5340251-$ or US-3878599-$ or US-3469613-$ or US-3253631-$ or US-2486769-$ or US-4690599-$ or US-3926236-$ or US-3999659-$ or US-3878598-$ or US-2206740-$ or US-2096623-$ or US-6325584-$ or US-4221041-$ or US-2465534-$ or US-0371884-$ or US-6108890-$ or US-4130922-$ or US-6581259-$).did. or (EP-28019-$).did. or (DE-3447006-$).did.	USPAT; EPO; DERWENT	2004/01/30 18:30
-	5	3447006.URPN.	USPAT	2004/01/30 18:28
-	2	("4633560").PN.	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 18:33
-	10	("0445238" | "1105872" | "1502868" | "3432925" | "3800401" | "3938239" | "4018257" | "4039099" | "4064617" | "4078413").PN.	USPAT	2004/01/30 18:30
-	0	("threadedadjrodstock").PN.	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 18:33
-	0	threaded adj rodstock	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 18:33
-	51012	thread$3 near2 rod	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 18:34
-	0	thread$3 near2 rodstock	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 18:34
-	27535	threaded adj rod	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 18:34
-	12	(threaded adj rod) with headless	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 18:35
-	0	((threaded adj rod) with (head or cap) with hollow) same (flangeless or no adj flange)	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 18:36
-	107	(threaded adj rod) with (head or cap) with hollow	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 18:41

-	34	(threaded adj rod) with (head or cap) with taper$3	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 18:41
-	7233	(bolt and (body or shank or shaft) and (head or cap)) and (head or cap) with hollow	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 18:55
-	109	self adj piercing adj rivet	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 18:55
-	9617	((fastener or rivet or bolt) and (cavity or hollow) with (head or cap)) and (cavity or hollow) near3 (head or cap)	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 18:56
-	14201	((bolt and (body or shank or shaft) and (head or cap)) and (head or cap) with hollow) or (self adj piercing adj rivet) or (((fastener or rivet or bolt) and (cavity or hollow) with (head or cap)) and (cavity or hollow) near3 (head or cap))	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 18:56
-	0	(thread$3 near2 rodstock) and (annul$3 with fold$3)	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 18:57
-	0	(thread$3 near2 rodstock) and (annul$3 with groove)	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 18:57
-	0	((thread$3 near2 rodstock) and (annul$3 with fold$3)) and (annul$3 with fold$3)	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 18:58
-	71	(((bolt and (body or shank or shaft) and (head or cap)) and (head or cap) with hollow) or (self adj piercing adj rivet) or (((fastener or rivet or bolt) and (cavity or hollow) with (head or cap)) and (cavity or hollow) near3 (head or cap))) and (annul$3 with fold$3)	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 18:58
-	1849	(((bolt and (body or shank or shaft) and (head or cap)) and (head or cap) with hollow) or (self adj piercing adj rivet) or (((fastener or rivet or bolt) and (cavity or hollow) with (head or cap)) and (cavity or hollow) near3 (head or cap))) and (annul$3 with groove)	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 18:59
-	1883	((((bolt and (body or shank or shaft) and (head or cap)) and (head or cap) with hollow) or (self adj piercing adj rivet) or (((fastener or rivet or bolt) and (cavity or hollow) with (head or cap)) and (cavity or hollow) near3 (head or cap))) and (annul$3 with fold$3)) or ((((bolt and (body or shank or shaft) and (head or cap)) and (head or cap) with hollow) or (self adj piercing adj rivet) or (((fastener or rivet or bolt) and (cavity or hollow) with (head or cap)) and (cavity or hollow) near3 (head or cap))) and (annul$3 with groove))	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 18:59

-	446	(((((bolt and (body or shank or shaft) and (head or cap)) and (head or cap) with hollow) or (self adj piercing adj rivet) or (((fastener or rivet or bolt) and (cavity or hollow) with (head or cap)) and (cavity or hollow) near3 (head or cap))) and (annul$3 with fold$3)) or (((bolt and (body or shank or shaft) and (head or cap)) and (head or cap) with hollow) or (self adj piercing adj rivet) or (((fastener or rivet or bolt) and (cavity or hollow) with (head or cap)) and (cavity or hollow) near3 (head or cap))) and (annul$3 with groove))) and (annul$3 with (fold$3 or groove)) same (join$3 or fasten$3 or rivet$4)	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 19:00
-	172	((((((bolt and (body or shank or shaft) and (head or cap)) and (head or cap) with hollow) or (self adj piercing adj rivet) or (((fastener or rivet or bolt) and (cavity or hollow) with (head or cap)) and (cavity or hollow) near3 (head or cap))) and (annul$3 with fold$3)) or (((bolt and (body or shank or shaft) and (head or cap)) and (head or cap) with hollow) or (self adj piercing adj rivet) or (((fastener or rivet or bolt) and (cavity or hollow) with (head or cap)) and (cavity or hollow) near3 (head or cap))) and (annul$3 with groove))) and (annul$3 with (fold$3 or groove)) same (join$3 or fasten$3 or rivet$4)) and (annul$3 with (fold$3 or groove)) with (join$3 or fasten$3 or rivet$4)	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/01/30 19:00
-	31	(US-3686914-$ or US-6276040-$ or US-6220804-$ or US-5340251-$ or US-3878599-$ or US-3469613-$ or US-3253631-$ or US-2486769-$ or US-4690599-$ or US-3926236-$ or US-3999659-$ or US-3878598-$ or US-2206740-$ or US-2096623-$ or US-6325584-$ or US-4221041-$ or US-2465534-$ or US-0371884-$ or US-6108890-$ or US-4130922-$ or US-6581259-$ or US-4039099-$ or US-6042313-$ or US-5333980-$ or US-4826372-$ or US-3789728-$).did. or (US-20030123947-$).did. or (EP-28019-$).did. or (DE-3447006-$ or GB-2341654-$ or US-4204308-$).did.	USPAT; US-PGPUB; EPO; DERWENT	2004/01/30 19:19
-	11	("2038189" | "2061628" | "2435144" | "2526235" | "3148578" | "3178989" | "3253495" | "4012984" | "4127345" | "4230017" | "4432679").PN.	USPAT	2004/01/30 19:21

US006213699B1

(12) United States Patent
Sadri et al.

(10) Patent No.: US 6,213,699 B1
(45) Date of Patent: Apr. 10, 2001

(54) FILLING RIVET WITH HIGH PIN LOCK

(75) Inventors: Shahriar M. Sadri, San Clemente; Lloyd Parker, Jr., Corona, both of CA (US); Gerhart Hufnagl, Tucson, AZ (US)

(73) Assignee: Huck International, Inc., Tucson, AZ (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: 09/393,428

(22) Filed: Sep. 10, 1999

(51) Int. Cl.[7] F16B 13/04; F16B 13/06

(52) U.S. Cl. 411/43; 411/34; 411/69

(58) Field of Search 411/34–38, 43, 411/69, 70

(56) References Cited

U.S. PATENT DOCUMENTS

2,538,623	1/1951	Keating .	
3,288,016	11/1966	Reynolds .	
3,292,482	12/1966	Fry et al. .	
3,298,725	1/1967	Boteler .	
3,377,907	4/1968	Hurd .	
3,390,601	7/1968	Summerlin .	
3,515,419	6/1970	Baugh .	
3,702,088	11/1972	Schmitt .	
4,046,053	9/1977	Alvi et al. .	
4,089,249 *	5/1978	Binns	411/43 X
4,355,934	10/1982	Denham et al. .	
4,405,273	9/1983	Ruhl et al. .	
4,627,775	12/1986	Dixon .	
4,639,174	1/1987	Denham et al. .	
4,781,500	11/1988	Mauer .	
4,789,283	12/1988	Crawford .	
4,846,611	7/1989	Sadri et al. .	
4,863,325	9/1989	Smith .	
4,904,133	2/1990	Wright .	
4,969,785	11/1990	Wright .	
5,054,977	10/1991	Schultz .	
5,102,274 *	4/1992	Norton et al.	411/43
5,286,151	2/1994	Eshraghi .	
5,503,510	4/1996	Golan .	
5,810,530	9/1998	Travis .	

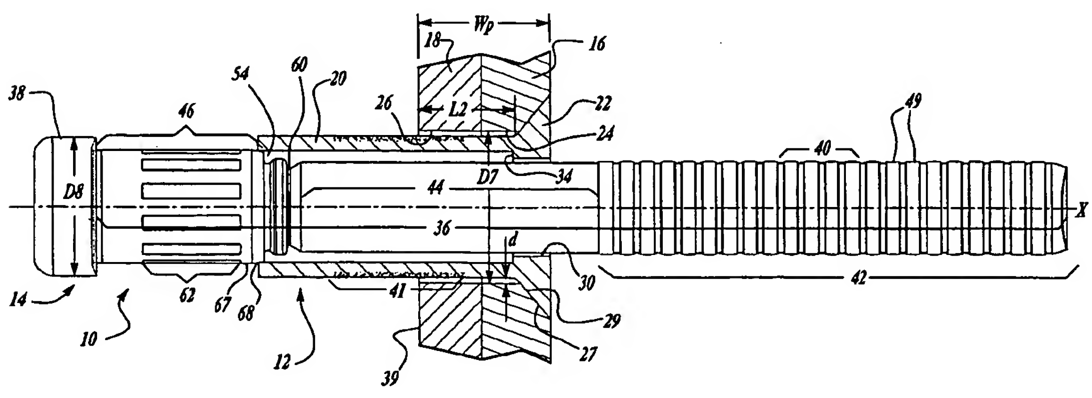
* cited by examiner

Primary Examiner—Neill Wilson
(74) Attorney, Agent, or Firm—Harness, Dickey & Pierce P.L.C.

(57) ABSTRACT

A two piece blind fastener for securing a plurality of workpieces including a hollow sleeve having a straight shank with an enlarged sleeve head at one end and a pin having an enlarged pin head; the pin has a pin stop shoulder and a lock groove located near the pin stop shoulder; the pin head is adapted to engage the sleeve to form a bulb type blind head in response to a relative axial force applied between the pin and sleeve; the pin stop shoulder is adapted to engage a sleeve stop shoulder to direct the material of the sleeve stop shoulder substantially radially inwardly into the lock groove to lock the pin and sleeve together and to finally form a stop surface on the sleeve for stopping axial movement of the pin through the sleeve; in addition the pin has an expander portion adapted to expand the sleeve shank radially outwardly to fill the openings of the workpieces and with the expander portion having a grooved section with alternate relief grooves and expander segments with the relief grooves receiving excess material of the sleeve after hole fill and to thereby also assist in locking the pin and sleeve together.

30 Claims, 5 Drawing Sheets



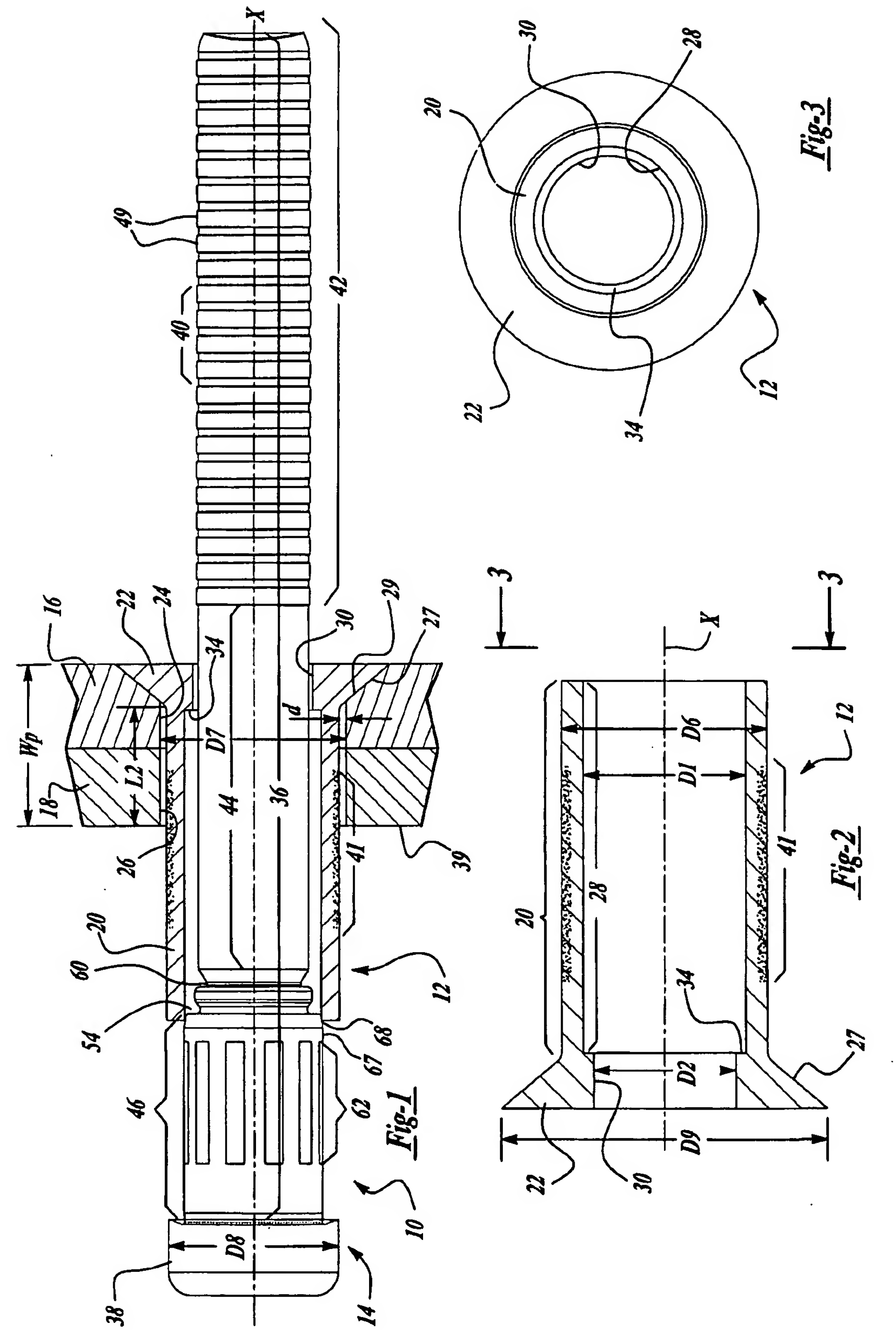


Fig-1

Fig-2

Fig-3

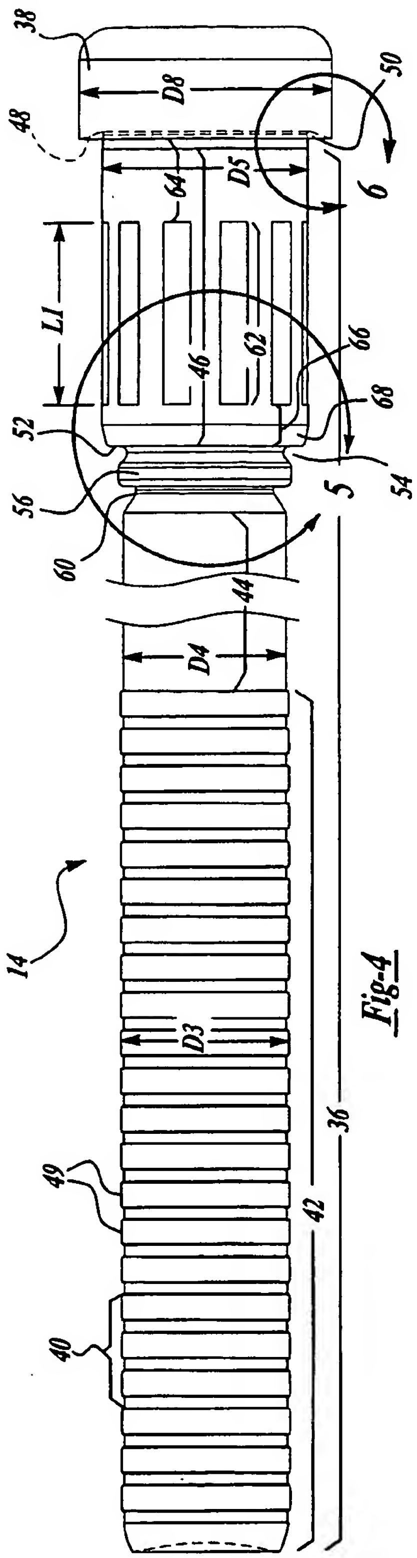


Fig-4

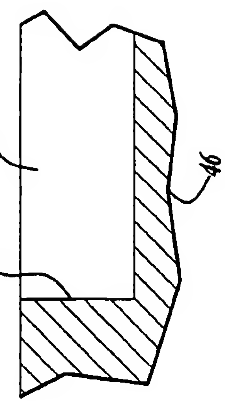


Fig-5b

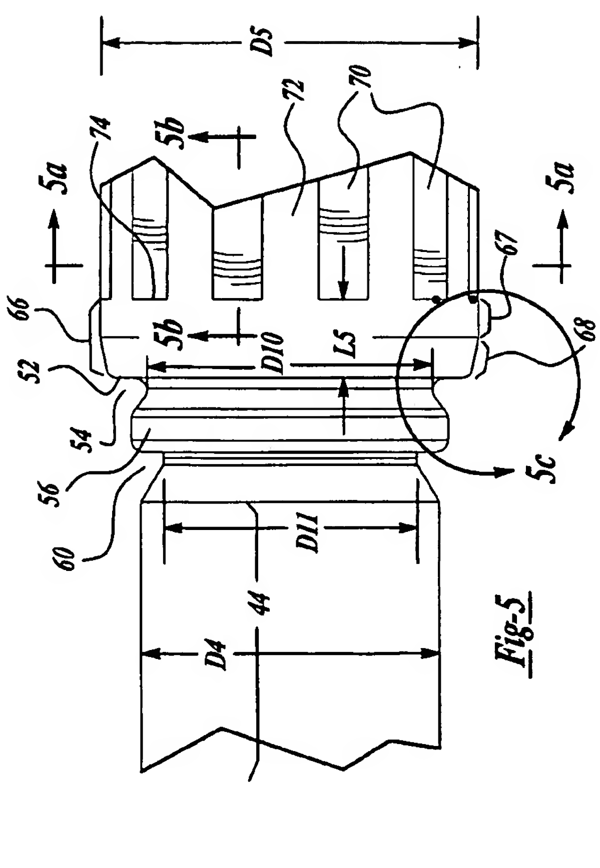


Fig-5

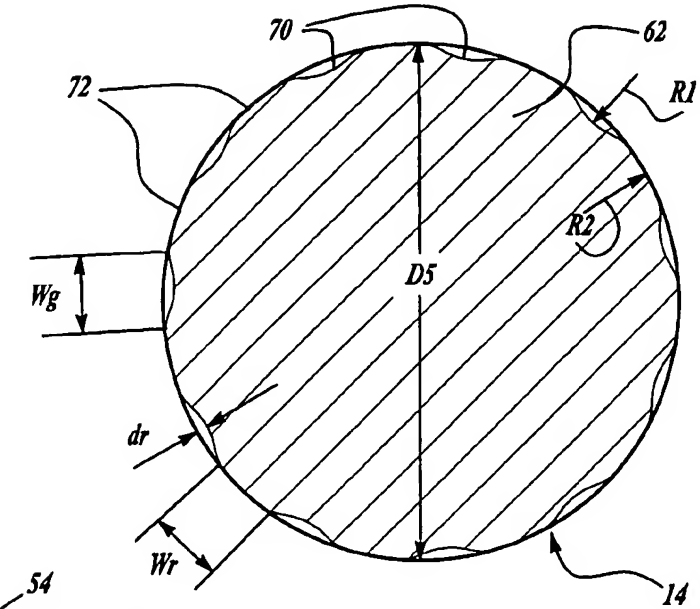


Fig-5a

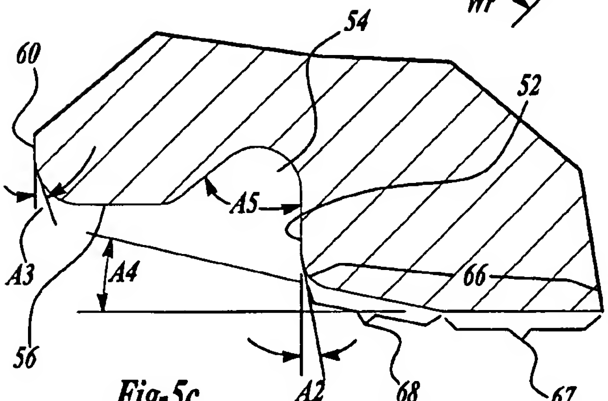


Fig-5c

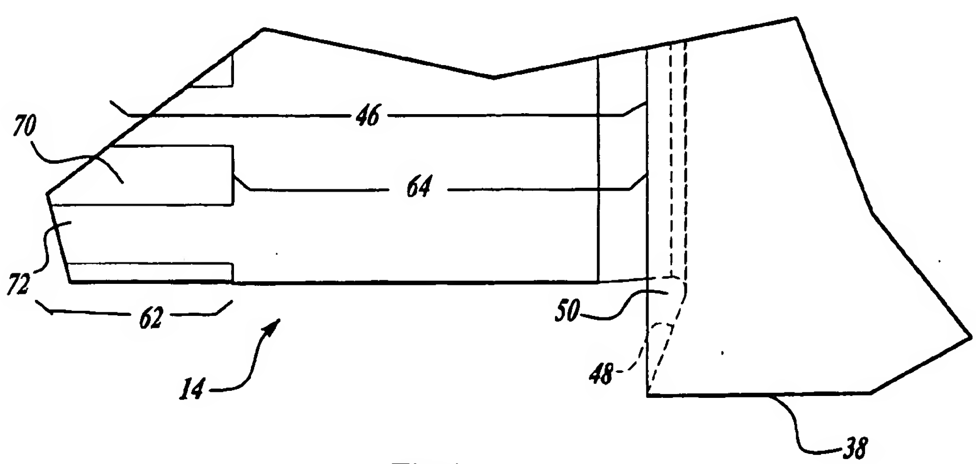


Fig-6

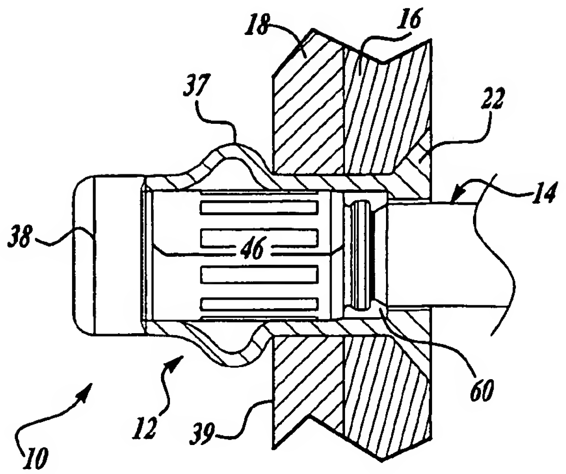


Fig-7a

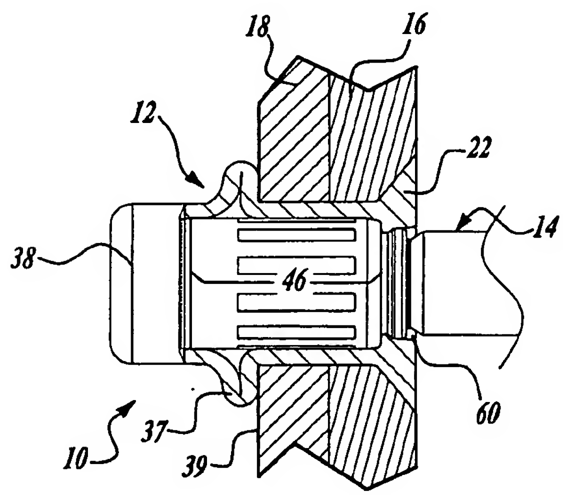


Fig-7b

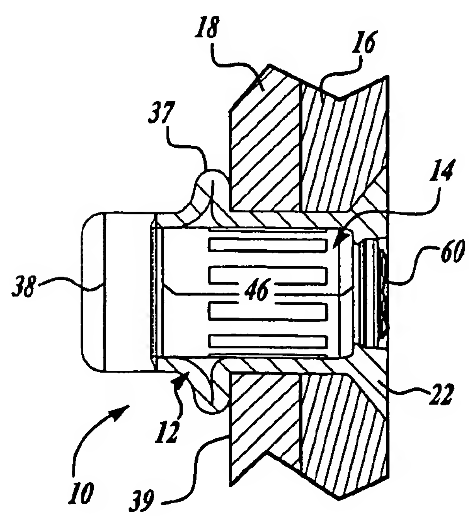


Fig-7c

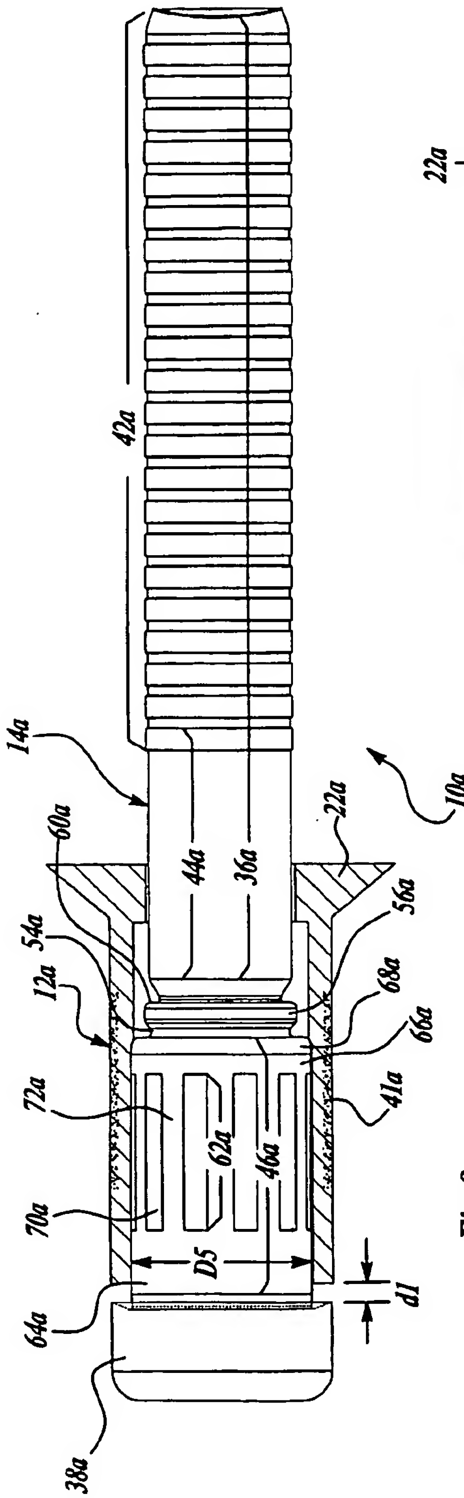

42a
14a
10a
22a
60a
44a
36a
56a
54a
12a
68a
66a
72a
41a
62a
46a
70a
D5
d1
64a
38a

Fig-8

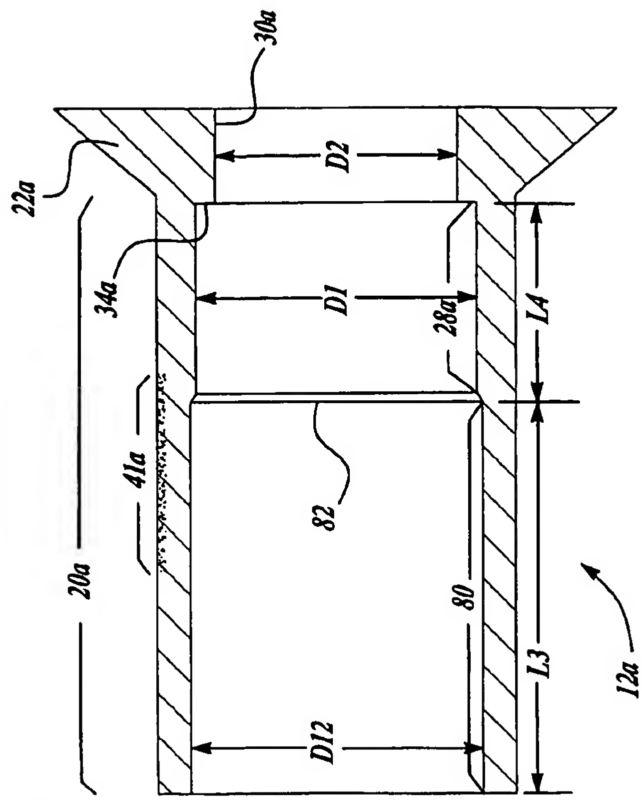

30a
D2
22a
34a
D1
28a
L4
41a
82
20a
80
L3
12a
D12

Fig-9

FILLING RIVET WITH HIGH PIN LOCK

BACKGROUND OF THE INVENTION

The present invention relates to blind fasteners and more particularly to blind fasteners including a pin and a sleeve and having a mechanical lock structure for locking the pin and sleeve together and providing a hole fill of the openings of workpieces being secured together.

In many blind fastener applications it is desirable that the pin and sleeve be mechanically locked together to inhibit loosening, separation and/or loss of the pin through vibration, etc. Examples of such blind fasteners can be seen in the U.S. Pat. No. 4,863,325 for Two Piece Blind Fastener With Lock Spindle Construction Issued on Sep. 5, 1989 to Smith, U.S. Pat. No. 4,046,053 for Blind Rivet issued on Sep. 6, 1977 to Alvi et al, U.S. Pat. No. 3,288,016 for Blind Two-Piece Fastener issued on Nov. 29, 1966 to Reynolds, and U.S. Pat. No. 2,538,623 for Rivet Assembly issued on Jan. 16, 1951 to Keating.

It is also desirable in many applications to fill the workpiece openings. This is frequently done by radially expanding and compressing the shank of the sleeve against the surface of the workpiece openings by an expander portion of the pin. Various forms of such structures are also shown in the patents noted above.

BRIEF SUMMARY OF THE INVENTION

In the present invention a blind fastener, including a pin and a sleeve, is provided in which an internal portion of the sleeve is moved radially inwardly during installation by a portion of the pin into a lock pocket groove on the pin to form a primary lock holding the pin and sleeve together.

In addition, the pin has an elongated expander portion which operates with the portion of the sleeve shank in the workpiece openings to radially expand that sleeve portion to fill the workpiece openings. The sleeve shank portion is formed with a volume of material which in combination with the volume of the expander pin portion defines a volume greater than that required to fill the workpiece openings. At the same time, the expander pin portion is formed with a grooved section having plurality of axially extending, circumferentially disposed relief grooves separated by co-extensively extending expander segments located in a common circular plane. The relief grooves are adapted to receive the excess material of the sleeve shank portion after hole fill caused by the expander pin portion. The hole fill is caused primarily, by the expander segments and by a straight, circumferentially continuous, straight expander segment at the leading end of the expander grooved section. In this regard, the expander portion is provided to be of a length such that the relief grooves will extend partially past the inner or blind side workpiece surface of the workpieces to thereby provide additional volume to receive excess sleeve shank material. This provides an increased tolerance range for dimensional variations in the workpiece openings and related fastener while still providing a desired magnitude of compression of the expanded collar material against the workpiece openings over the increased tolerance range. In this regard an excess magnitude of compression cr an insufficient magnitude of compression could have an adverse affect on the installation, performance and/or strength of the fastener and fastened joint. For example an excessive volume could cause axial movement of the sleeve head away from engagement with the adjacent work piece surface resulting in an unsatisfactory, weakened joint. This type of occurrence is

frequently referred to as "head rise". This is inhibited by the present invention. In addition to providing the increased tolerance range noted, the relief grooves are also formed to provide an additional or secondary lock between the pin and sleeve by virtue of the sleeve material flowing into the relief grooves during hole fill. This increases the overall lock between the pin and sleeve.

At the same time the extra lock provides additional resistance to "pin bounce" and its adverse effects which can occur as a result of severing the pin tail or pull portion of the pin by fracturing of a breakneck groove.

In the present invention the expander portion of the pin has a generally circular cross-section. The relief grooves are generally shallow and are of a generally arcuate contour. The expander segments separating each of the grooves are in a circular plane of the overall circular contour of the expander portion with both the expander segments and grooves being wide and generally of the same circumferential width. As will be seen this structure enhances the expansion capability of the expander portion while substantially resisting distortion.

In addition, the unique structure of the expander portion also enhances the work hardening and hence strength of the expanded sleeve shank portion in the workpiece openings arid additionally provides significant work hardening and hence strength to the material of the workpieces at the workpiece openings which are subject to hole fill. This provides substantially improved static strength and fatigue life of the fastener, the workpieces and hence of the fastened joint.

Thus it is an object of the present invention to provide a novel two piece blind fastener, including a pin and a sleeve, and in which the pin and sleeve are adapted to provide hole fill of the workpiece openings and are mechanically locked together by material from the sleeve which is moved radially inwardly into a lock pocket in the pin and with an additional lock formed by the excess material from the expanded shank portion of the sleeve moved into relief grooves in the expander portion of the pin shank from hole fill.

It is still another object of the present invention to provide a novel two piece fastener, including a pin and a sleeve, and in which a shank portion of the sleeve is adapted to be radially expanded by the pin into compressive engagement with the workpiece openings and with the pin having a structure for expanding the sleeve shank portion and which is adapted to accept excess sleeve material from the compressive engagement in expansion whereby the fastener can be used to secure workpieces having an increase in the range of tolerance variations in the size of the workpiece openings.

It is a further object of the present invention to provide a novel two piece fastener, including a pin and a sleeve, and in which a shank portion of the sleeve is adapted to be radially expanded by an expander portion of the pin into compressive engagement with the workpiece openings and with the expander portion having a plurality of axially extending generally wide relief grooves circumferentially separated by relatively wide expander segments with the relief grooves adapted to accept excess sleeve material from the compressive engagement in expansion generally without distortion of the ridges whereby the fastener can be used to effectively secure workpieces having an increase in the range of tolerance variations in the size of the workpiece openings and fastener components while resulting in increased static strength and fatigue life of the fastened joint.

It is another object of the present invention to provide a novel, dual mechanical locking structure for the pin and

sleeve of a two piece blind fastener and having an increased tolerance range for filling related workpiece openings.

It is a general object of the present invention to provide a new and improved two piece blind fastener.

Other objects, features, and advantages of the present invention will become apparent from the subsequent description and the appended claims, taken in conjunction with the accompanying drawings, in which:

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

FIG. **1** is a side elevational view with some parts shown in section of a blind fastener, including a pin and a sleeve embodying features of the present invention and with the pin and sleeve being in an initially pre-assembled relationship together and assembled with workpieces to be secured prior to initiation of installation;

FIG. **2** is a side elevational, longitudinal sectional view of the sleeve of FIG. **1**;

FIG. **3** is an elevational end view of the sleeve of FIGS. **1** and **2** taken generally in the direction of the Arrows **3—3** in FIG. **2**;

FIG. **4** is a side elevational view of the pin of FIG. **1**;

FIG. **5** is a fragmentary view to enlarged scale of the portion of the pin of FIG. **4** taken generally in the Circle **5** in FIG. **4**;

FIG. *5a* is a sectional view to enlarged scale of the pin of FIGS. **4** and **5** taken generally in the direction of Arrows *5a—5a* in FIG. **5** and depicting the contour of the relief grooves and expander segments of the expander pin portion of the pin with the relief grooves adapted to receive an excess of material of the sleeve shank from expansion in hole fill;

FIG. *5b* is a fragmentary sectional view to enlarged scale taken generally in the direction of the Arrows *5b—5b* in FIG. **5** and further depicting the contour of the relief grooves of the expander pin portion of the pin;

FIG. *5c* is a fragmentary view to enlarged scale of the lead-in segment of the expander pin portion taken generally in the Circle 5c FIG. **5**;

FIG. **6** is a fragmentary view to enlarged scale taken generally in the Circle **6** in FIG. **4** and depicting a portion of the enlarged head of the pin;

FIGS. *7a*, *7b* and *7c* are sequence views of the fastener and workpieces of FIG. **1** and depicting the fastener in the progressive stages of installation after the initial pre-assembly in FIG. **1** prior to initiation of installation to subsequent sequential stages of installation in FIGS. *7a* and *7b* to completion of installation at FIG. *7c;*

FIG. **8** is a side elevational view similar to FIG. **1** and including the pin of FIG. **1** in a pre-assembled relationship with a sleeve of modified construction; and

FIG. **9** is a side elevational, sectional view to enlarged scale of the modified sleeve of FIG. **8**.

DETAILED DESCRIPTION OF THE INVENTION

As can be seen in FIG. **1**, a blind fastener **10**, includes a hollow sleeve **12** and a pin **14** which are shown in a pre-assembled relationship to facilitate handling and as pre-assembled to workpieces **16** and **18**.

Looking now to FIGS. **1–3**, the hollow sleeve **12** has a generally straight shank **20** of a uniform outside diameter D6 which terminates at its forward end in an enlarged head **22**. As can be seen in FIG. **1**, the sleeve shank **20** is adapted to fit in clearance relationship in through bores or aligned openings **24** and **26** in workpieces **16** and **18**, respectively. The enlarged head **22** is of a conical, flush head type construction and has a tapered inner surface **27** which tapers radially inwardly from a head diameter D9 and is adapted to fit matingly within a tapered countersunk opening **29** at the outer end of bore **24** in workpiece **16**. While a conical, flush head **22** is shown it should be understood that the present invention is equally applicable to a sleeve having a protruding head.

Sleeve **12** has a central through bore which includes a shank bore portion **28**, having a diameter D1, which extends generally uniformly for the length of the sleeve shank **20** and communicates proximate the enlarged sleeve head **22** with a generally uniform, reduced diameter bore portion **30**, of a diameter D2. An annular stop shoulder **34** is defined at the juncture of shank bore portion **28** and the reduced diameter bore portion **30**. The stop shoulder **34** extends radially inwardly substantially transversely to the central axis X of the sleeve **12** and pin **14** of the fastener **10**.

As will be seen, it is desirable that a blind head be formed by upsetting the sleeve shank **20** radially outwardly at a point along its length to form a bulbed blind head **37** as shown in FIG. *7c*. The blind head **37**, however, is to engage the blind side, inner surface **39** of the workpiece **18** and this is to occur over a range of total thickness Wp of the workpieces **16** and **18** able to be secured by one size of the fastener **10**. This is referred to as the "grip range" for that fastener. To achieve this, the sleeve shank **20** is band annealed over an intermediate section **41** to provide a gradient of reduced hardness. In this regard the sleeve **12** is formed by cold heading blanks which results in an increase in hardness of the material in the sleeve shank **20** from cold working; this hardness is reduced in the intermediate section **41** by band annealing as noted. This then facilitates bulbing in the section **41** to form the blind head **37** having the desired bulbed configuration in clamping engagement with the blind side surface **39**. The section **41** extends generally from a location to be proximate to the blind side surface **39** rearwardly to provide an ample range for formation of the bulbed blind head **37** over the desired range of the overall workpiece thickness Wp.

Looking now to FIGS. **1**, **4**, **5**, *5a–5c* and **6** the pin **14** has an elongated shank **36** which terminates in an enlarged pin head **38** at its rearward end (the blind end of fastener **10**); the shank **36** of pin **14** has a plurality of annular pull grooves **40** in a pull groove portion **42** at the opposite end connected to a smooth shank portion **44**. The shank **36** includes an expander pin portion **46** connected at one end to the pin head **38**.

Since the pull grooves **40** are formed by roll forming on an extension of the smooth shank portion **44**, the diameter D3 of the crests **49** of the pull grooves **40** is slightly greater than the diameter D4 of the smooth shank portion **44**. At the same time the diameter D5 of the expander pin portion **46** is greater than diameters D3 and D4 of the crests **49** of pull grooves **40** and of the smooth shank portion **44**, respectively. The diameters D3 and D4 of pin shank portions **42** and **44** are less than the small diameter D2 of the reduced diameter bore portion **30** of sleeve **12** whereby the shank portions **42** and **44** can pass freely through the sleeve **12**. On the other hand the diameter D5 of expander pin portion **46** is greater than the diameter D1 of the shank bore portion **28** to provide a predetermined amount of sleeve shark expansion during installation resulting in hole fill of the bores **24** and **26** of workpieces **16** and **18**, respectively, in a manner to be

described. In this regard the outside diameter D6 of the straight sleeve shank 20 is less than the diameter D7 of workpiece bores 24 and 26 to provide a radial clearance distance d, i.e. ½ (D7–D6), see FIG. 1. As will be seen the present invention provides effective hole fill and fastener installation over an increased range in clearance d.

Looking now to FIG. 6, the pin head 38 has a radially inwardly, axially rearwardly tapered guide surface 48 which defines an annular cavity 50 within the head 38. The guide surface 48 is essentially planar extending radially inwardly and axially rearwardly at an angle A1 relative to a plane transverse to the axis X. The outside diameter D8 of the pin head 38 is generally around that of the outside diameter D6 of the sleeve shank 20 and thus, in installation, the outer or free end of the sleeve shank 20 will be engaged by the tapered pin guide surface 48 and thereby guided radially inwardly into the pin cavity 50. Thus this guiding action inhibits movement of the sleeve shank 20 radially outwardly over the pin head 38 and thereby assists in the formation of the blind head in a desired bulbed configuration to be described. See bulbed blind head 37 in FIG. 7c.

An annular pin stop shoulder 52 is defined at the end of the expander pin portion 46 and is generally planar. (See FIG. 5). A lock pocket groove 54 is defined by an annular groove of a reduced diameter D10 located immediately adjacent the sleeve pin stop shoulder 52 with the outer end of the lock pocket groove 54 being defined by an annular land 56. Axially outwardly from the lock pocket 54 and adjacent to the annular land 56 is an annular breakneck groove 60 of a reduced diameter D11 which defines the weakest section of the pin 14. The inner end of the breakneck groove 60 is at a planar surface at the outer end of the land 56. Both the pin stop shoulder 52 and inner surface of the breakneck groove 60 are in planes transverse to the axis X of pin 14 or slightly angulated axially rearwardly and radially outwardly, i.e. at angles A2 and A3, respectively, relative to such transverse planes. (See FIG. 5c). In addition the lock pocket groove 54 is formed with a relatively large included angle A5. This construction facilitates rolling of the lock pocket groove 54 and breakneck groove 60. At the same time the angles A2, A3 and A5 are selected to inhibit extrusion during installation and to provide for a clean break line at the breakneck groove 60 upon fracture at the completion of installation.

Looking now to FIGS. 4, 5, 5a, 5b and 6 the expander pin portion 46 is of a circular cross section. The expander pin portion 46 comprises a grooved section 62 which is connected at one end to the pin head 38 by a first, inner smooth section 64 and at the other end to the stop shoulder 52 by a second, outer smooth section 66. The second, outer smooth section 66 terminates in a tapered lead-in segment 68 at its outer end. The grooved section 62, and first and second smooth sections 64 and 66 are substantially of the same diameter D5 except for the lead-in segment 68. The lead-in segment 68 tapers radially inwardly at an angle A4 relative to the axis X. The taper angle A4 is selected to facilitate initial movement of the expander pin portion 46 into the free end of the sleeve shank 20 and at the same time facilitates the radial outward expansion of the sleeve shank 20 at an acceptable relative axial force for installation. In this regard the lead-in segment 68 formed as noted avoids galling of the inside surface of shank bore portion 28.

In this regard and as noted, the diameter D5 of the expander pin portion 46 is larger than the diameter D1 of the bore portion 28 of sleeve shank 20. However, in the pre-assembly together of the sleeve 12 and pin 14 the tapered lead-in segment 68 of the expander pin portion 46 is located only partially in interference within the bore portion 28 and while holding the sleeve 12 and pin 14 together to facilitate handling prior to installation it does so without excessive expansion of the sleeve 12 whereby insertion of the pre-assembled fastener 10 into workpiece openings 24 and 26 is not inhibited (see FIG. 1). In this regard, it is believed that the outer surface of the sleeve shank could be slightly tapered to a reduced thickness at the open end to accommodate such pre-assembly without creating interference with workpiece openings 24 and 26 upon initial insertion.

The grooved section 62 is formed to have axially extending relief grooves 70 and expander segments 72. The grooves 70 are relatively shallow and have an arcuate contour with a generous radius R1 and with a shallow radial depth of dr. The expander segments 72, however, are maintained with a curvature of the overall diameter D5 being a radius R2. The relief groove radius R1 blends smoothly with the arcuate contour of the overall radius R2 of the expander segments (i.e. R2≈½ D5). In this regard, in one form of the invention the radius R1 was selected to be around 30% of the radius R2. At the same time the radial depth dr of the shallow relief grooves 70 was between around 2% to around 2.5% of the overall diameter D5. Thus the curvature of the relief grooves 70 is selected to facilitate the flow of the excess sleeve material from hole fill while at the same time the relatively shallow construction assists in maintaining the compression of the sleeve material in the grooves 70 against the inner surfaces of the workpiece openings 24, 26.

As noted the relief grooves 70 are relatively wide circumferentially and thus the circumferential groove width Wg is substantially equal to the circumferential width Wr of the expander segments 72. At the same time, in one form of the invention, the width Wg of relief grooves 70 and width Wr of expander segments 72 extend circumferentially for around 16° each. In this regard, the volume of the grooves 70 is selected to be slightly less than the volume of sleeve material, in combination with the volume of the expander pin portion 46, which is in excess of that required to fill the radial gap d at the end of the dimensional tolerance range where d is a minimum. At the same time the relief grooves 70 will be at least partially filled when filling the radial gap d at the other end of the dimensional tolerance range where d is a maximum.

As noted, the outer smooth section 66 terminates in the tapered lead-in segment 68 at the leading end of the expander pin portion 46. The smooth section 66 has a straight segment 67 which is of the fill diameter D5. The smooth section 66 is of a relatively short axial length L5 and in this regard in one form of the invention the axial length L5 was about 20% of the expansion diameter D5. At the same time the tapered lead-in segment was generally around 50% of the length L5. This still left a short, limited length for the straight segment 67. It is believed that this short, straight segment 67 provides a limited, desired length of full circumferential expansion of the sleeve shank 20 prior to the engagement by the grooved section 62. The limited segment 67 then initially provides uniform hole fill of the workpiece openings 24 and 26 and facilitates flow of the excess sleeve material into the relief grooves 70. At the same time the combination of the smooth surface of the straight segment 67 and the generally uniform, circumferentially wide surfaces of the expander segments 72 inhibit cutting of grooves or notches in the engaged, expanded surface of the sleeve shank 20.

The overall axial length L1 of the grooved section 62 is selected such as to be substantially fully in line with the straight workpiece bores 24 and 26 in the condition of

maximum grip where the total thickness Wp of the workpieces **16**, **18** is a maximum for the fastener **10** and with the length L2 of the straight portions of workpiece bores **24** and **26** being generally less than the length L1 of the grooved section **62**. In this regard the length L1 of the grooved section **62** is selected such that it will extend partially past the blind side surface **39** even in a maximum grip condition, i.e. where the combined thickness Wp is a maximum for that fastener. This provides an additional volume of relief grooves **70** to receive excess sleeve material in conditions where the radial gap d is at a minimum. In the drawings of FIGS. 1 and 7*a*–7*c* the thickness Wp of the workpieces **16** and **18** is shown generally at a nominal value in the grip range between the minimum and maximum magnitude of the total thickness Wp.

The relief grooves **70** are formed by rolling a straight pin shank portion of the diameter D5. As the grooves **70** are formed the material displaced in forming the grooves **70** moves substantially in axial elongation whereby the diameter D5 is maintained overall for the expander pin portion **46**, i.e. for the expander segments **72** of the grooved section **62** and the first and second smooth sections **64** and **66** up to the tapered lead-in segment **68**. The pin **14** is then heat treated after rolling to provide a uniform desired hardness.

Looking now to FIG. 5*b* the leading end of the relief grooves **70** terminates in a generally planar end surface **74** which is generally transverse to the axis X. This creates an abutment for the excess material which flows into the relief grooves **70**. Thus the abutment creates a secondary lock resisting push out of the pin **14** from the sleeve **12** and assists in holding the pin **14** and sleeve **12** of fastener **10** together after installation.

The fastener **10** is adapted to be set by an installation tool which can be of a type well known in the art and hence the details thereof have been omitted for simplicity. However, it should be noted that the tool has a chuck jaw assembly which is adapted to grippingly engage the pull grooves **40** of the pin **14** while an anvil engages the enlarged sleeve head **22**. Upon actuation of the tool, the jaw assembly moves axially away from the anvil whereby a relative axial force is applied between the pin **14** and sleeve **12**.

As this relative axial force increases in magnitude, the pin **14** is pulled into the sleeve **12** and the expander pin portion **46** is moved into the end of the sleeve shank **20** until the pin head **38** engages the outer end of the sleeve shank **20**. At this point the annealed section **41** of sleeve shank **20** begins to bulb radially outwardly to initiate formation of a bulbed blind head **37**. (See FIG. 7*a*). As this occurs the expander pin portion **46** is moved into the sleeve bore portion **28** with the tapered lead-in segment **68** assisting in piloting of the expander pin portion **46** into the sleeve bore portion **28** while facilitating radial expansion of the sleeve shank **20**.

As axial movement of the pin **14** continues the pin stop shoulder **52** engages the sleeve stop shoulder **34** moving material from the sleeve stop shoulder **34** radially inwardly into the lock pocket groove **54**. After the lock pocket groove **54** has been substantially filled, movement of the pin **14** is arrested. At this point the bulbed blind head **37** has been fully formed and is in clamping engagement with the blind side, inner surface **39** of workpiece **18**. (See FIG. 7*b*). Now as the relative axial force applied between the pin **14** and sleeve **12** increases a force of preselected magnitude is reached at which the pin **14** is fractured at the breakneck groove **60** and the pull groove portion **42** is removed. This then completes the installation. (See FIG. 7*c*). At the same time the secondary lock formed by the sleeve material which has flowed into the relief grooves **70** assists the primary lock by the sleeve material in the lock pocket **54** to resist loosening of the pin **14** and sleeve **12** from pin bounce occurring at fracture of the breakneck groove **60**. This improves the static strength of the fastened joint.

Note that the breakneck groove **60** and pin stop shoulder **52** are separated by a preselected distance such that when the pin stop shoulder **52** is held from farther axial movement by the sleeve stop shoulder **34**, the breakneck groove **60** will be located within the sleeve bore portion **30** such that upon fracture the outer, fractured end of the pin **14** will generally not extend beyond the adjacent outer surface of the sleeve head **22**.

The volume of the material of the sleeve stop shoulder **34** is selected relative to the volume of the lock groove **54** such that the lock groove **54** will be substantially filled and axial movement of the pin **14** will be stopped at the desired location generally when that filled condition occurs, i.e. such that pin break at breakneck **60** occurs within the sleeve head **22**. Thus the volume of sleeve stop shoulder **34** is generally greater than the volume necessary to fill the lock groove **54**.

The sleeve head **22** provides radial stiffness and resists any tendency for radial expansion of sleeve **12** as the sleeve stop shoulder **34** is deformed into the lock groove **54**. In this regard the breakneck groove **60** is designed to fracture at an axial load greater than that load at which the filling of the lock groove **54** occurs; thus after filling, the additional axial force necessary for pin break could urge the sleeve material to radially expand the sleeve **12**. This radial displacement of sleeve material could result in axial movement of the pin **14** making its final position more difficult to control. By locating the sleeve stop shoulder **34** substantially within the confines of the sleeve head **22**, such radial expansion is inhibited. At the same time, it should be noted that only the tapered lead-in segment **68** and perhaps a part of the straight segment **67** will move into the area of the sleeve head **22**. This spaces the grooved section **62** away from the sleeve head **22** thereby preventing deterioration in the strength of the sleeve **12** in the vicinity of the connection between the sleeve head **22** and sleeve shank **20**.

In this regard it is also believed desirable to have the lock groove **54** located very close and/or contiguous to the pin stop shoulder **52** in order to promote the effectiveness of its fill by the material of the sleeve stop shoulder **34**. It is also believed desirable that the forwardmost wall **76** of the lock groove **54** be axially spaced as far as possible from the breakneck groove **60** with both, of course, located substantially within the confines of the sleeve head **22** for reasons previously described.

The above construction promotes good filling of the lock groove **54** and also minimizes variations in the axial position of the pin **14** at which the lock groove **54** is filled and the shoulder stop is formed and hence permits consistency of location of the fracture of the breakneck groove **60** within the confines of sleeve head **22**.

In one form of the invention the pin **14** was made of A286 stainless steel having a hardness of around **44** Rc and sleeve **12** was made of C.P.Ti, i.e. commercially pure titanium, having a general hardness of 96 Rb. Alternatively the pin **14** could be made of a titanium alloy such as 6Al–4V (Aluminum/Vanadium) while the sleeve **12** could be made of a titanium alloy such as 3Al–2.5V or A286 stainless steel.

As noted the sleeve **12** is work hardened during formation by cold heading from a blank such as to increase the hardness of the sleeve shank **20** and after that the sleeve shank **20** is band annealed in a limited area to provide the band annealed section **41**. This facilitates formation of the bulbed blind head **37** at the desired location at the blind side surface **39** of workpiece **18**. In addition to the tapered lead-in segment **68** frictional affects can be further reduced by the use of a light coat of a lubricant on the pin **14** such as Kalgard FA, which is a trademarked product.

In aircraft applications the workpieces **16** and **18** are typically made of a lightweight material such as a 2024 T3 clad aluminum alloy or generally of aluminum alloys in the 2,000 or 7,000 series or of a titanium alloy. Thus the area around the workpiece openings **24** and **26** will be work hardened to an increased hardness by the compression of the expanded section of the sleeve shank **20**. In addition the segment of the band annealed section **41** which is located in and expanded and compressed in the workpiece openings **24** and **26** will also be work hardened to an increased hardness.

It should also be noted that the lock mechanisms of fastener **10** are performed by the interaction of pin **14** and sleeve **12** and are not dependent upon any special construction of the installation tool. However, the installation tool should preferably have a flat anvil surface adapted to engage the outer surface of the sleeve head **22**. In this regard while the fastener **10** is shown as being of a two piece construction, i.e. with sleeve **12** and pin **14**, it should be understood that a disposable anvil type load washer, such as shown in U.S. Pat. No. 5,810,530 issued Sep. 22, 1998 to Travis for Interference Blind Type Bolt and U.S. Pat. No. 4,789,283 issued Dec. 6, 1988 to Crawford for Fluid-Tight Blind Rivet, could be used to engage the sleeve head **22** to react the relative axial load applied to the sleeve **12**.

A list of representative typical values for one form of the sleeve **12** and pin **14** of fastener **10** is noted in the chart which follows. It should be understood that the following values are by way of example and that the principles of the present invention can be employed for fasteners of different sizes, dimensions, materials and the like with the noted values changing.

CHART OF TYPICAL VALUES - INCHES AND DEGREES						
	SLEEVE 12					
Material	Hardness Shank 20 General - Pre-Anneal	D1 Bore Portion 28	D2 Bore Portion 30	D6 Sleeve Shank 20	D9 Sleeve Head 22	Minimum Hardness Annealed Section 41
C.P. Titanium	96 Rb	0.147	0.129	0.185	0.300	70 Rb
			PIN 14			
Material	Hardness	D3 Pull Crests 49	D4 Smooth Shank 44	D5 Expander Portion 46	D8 Pin Head 38	A1 Guide Surface 48
A286 S.S.	44 Rc	0.124	0.120	0.152	0.185–.186	80°
A2 Stop Shoulder 52	A3 b'neck groove 60	D10 Lock Groove 54	D11 b'neck Groove 60	A4 Lead-in Segment 68	R1 Relief Grooves 70	R2 Expander Segments 72
0°–2°	0°–5°	0.116	0.098	10°	0.023	0.076
L1 Grooved Section 62	A5 Lock Pocket Included Angle	Wg Width Relief Groove 70	Wr Width Expander Segment 72	dr Radial Depth	dr/D5	L5
0.135	50°	16°	16°	.003	2–2.5%	.031
		WORKPIECES 16, 18				
Material	D7 Workpiece Bores 24,26	Clearance d 1/2 (D7-D6)	Wp Thickness Workpieces 16, 18			
2024 T3 Clad Al	0.188	.0015	0.125–0.188			

A modified embodiment of another preferred form of fastener **10** is shown in FIGS. **8** and **9**. In the description of the embodiment in FIGS. **8** and **9** components similar to like components in the embodiment of FIGS. **1–7** have been given the same numeral designation with the addition of the postscript letter "a" and unless described otherwise can be considered to be substantially the same. In this regard, the same designation shall be used for dimensions that are the same and unless noted otherwise the typical dimensions are the same as listed in the CHART OF TYPICAL VALUES for fastener **10**. As can be seen in FIGS. **8** and **9**, a blind fastener

10a, includes a hollow sleeve 12a and a pin 14a, and, in FIG. 8, is shown in a pre-assembled relationship to facilitate handling in preparation for installation of workpieces such as workpieces 16 and 18.

As will be seen the sleeve 12a is substantially the same as sleeve 12 except that sleeve 12a is provided with a counterbored portion 80 at the outer end of sleeve shank 20a. The counterbored portion 80 is of a diameter D12 which is slightly less than the diameter D5 of the expander pin portion 46a. For example with the pin 14a being dimensioned essentially the same as pin 14 and as set forth in the CHART OF TYPICAL VALUES the counterbore diameter D12 would be between around 0.150 to around 0.151 inches to provide a slight interference with a D5 of between around 0.1515 to around 0.1530 inches to facilitate pre-assembly of the pin 14a and sleeve 12a without significant sleeve shank expansion.

The counterbored portion 80 extends for a length L3 to a locating shoulder 82 at the juncture of counterbore portion 80 with the shank bore portion 28a. Here the shank bore portion 28a, while of reduced length, is the same as shank bore portion 28. Thus the pin shank 36a can be moved into the sleeve shank 20a in preassembly for the length L3 until the pin stop shoulder 52a is engaged with the locating shoulder 82. This will place the pin head 38a a slight preselected distance d1 from the end of the sleeve shank 20a to provide a visual indication of the desired pre-assembly. With this structure the smooth pin shank portion 44a can be reduced in length by the length L3 while still providing the same amount of accessibility of the shank pull portion 42a at the accessible side of the workpiece such as workpieces 16 and 18. At the same time the backside protrusion of the pin 14a at the blind side of the workpieces is reduced by the length L3 permitting use of the fastener 10a in applications having reduced blind side clearance. Also the overall length and cost of the pin 14a is reduced. Except as noted above the pin 14a is identical to pin 14 and the sleeve 12a is identical to sleeve 12.

Thus the sleeve 12a has a central through bore which includes a hole filling shank bore portion 28a, having a diameter D1, which extends generally uniformly for a length L4 of the sleeve shank 20a from the locating shoulder 82 to a point proximate to the enlarged sleeve head 22a with a generally uniform, reduced diameter bore portion 30a, of a diameter D2. The annular stop shoulder 34a is defined at the juncture of shank bore portion 28a and the reduced diameter bore portion 30a.

The sleeve shank 20a is band annealed over an intermediate section 41a to provide the gradient of reduced hardness to facilitate bulbing in the section 41a to form the blind head such as blind head 37.

Looking now to FIG. 8, the pin 14a is identical to pin 14, except for the smooth shank portion of 44a of reduced length. Thus the pin 14a has an elongated shank 36a which terminates in an enlarged pin head 38a at its rearward end; the shank 36a of pin 14a has a plurality of annular pull grooves 40a in a pull groove portion 42a at the opposite end connected to the smooth shank portion 44a. The shank 36a includes the expander pin portion 46a connected at one end to the pin head 38a.

As noted the diameter D5 of expander pin portion 46a is greater than the diameter D1 of the shank bore portion 28a to provide the predetermined amount of sleeve shank expansion during installation resulting in hole fill of the workpiece bores such as bores 24 and 26 of workpieces 16 and 18, respectively. In this regard the outside diameter D6 of the straight sleeve shank 20a is less than the diameter D7 of workpiece bores to provide the radial clearance distance d. As noted with fastener 10 the fastener 10a provides effective hole fill and fastener installation over an increased range in clearance d.

The pin head 38a is identical to pin head 38 and includes a radially inwardly, axially rearwardly tapered guide surface such as 48 which defines an annular cavity such as 50 which functions in the manner previously described.

An annular pin stop shoulder 52a, a lock pocket groove 54a, an annular land 56a, and an annular breakneck groove 60a are identical to their similarly numbered counterparts in pin 14.

The expander pin portion 46a is of a structure identical to expander pin portion 46 as shown and described in FIGS. 4, 5, 5a, 5b and 6. Thus the expander pin portion 46a comprises a grooved section 62a which is connected at one end to the pin head 38a by a first, inner smooth section 64a and at the other end to the stop shoulder 52a by a second, outer smooth section 66a. The second, outer smooth section 66a terminates in a tapered lead-in segment 68a at its outer end. The lead-in segment 68a tapers radially inwardly at the angle A4 relative to the axis X and serves the purpose previously described.

In this regard the reduced length L4 of the hole filling shank bore portion 28a is generally equal to the length L2 of the straight portion of the workpiece bores in the maximum grip or maximum total thickness Wp.

The grooved section 62a is formed to have axially extending relief grooves 70a and expander segments 72a which are identical to relief grooves 70 and expander segments 72.

Again the overall axial length L1 of the grooved section 62a is selected such as to be substantially fully in line with the straight portions of workpiece bores in the condition of maximum grip where the total thickness Wp of the workpieces is a maximum for the fastener 10a and with the length L2 of straight portions of workpiece bores being generally equal to the length L1 of the grooved section 62a. At the same time the counterbored shank portion 80 is provided to extend from the blind side surface, such as surface 39, generally for the length L3 in the minimum grip or maximum total thickness Wp condition.

The fastener 10a is adapted to be set in the same manner as fastener 10 by an installation tool and as previously described and hence the details thereof have been omitted for simplicity.

Thus after the lock pocket groove 54a has been substantially filled, movement of the pin 14a is arrested. At this point the bulbed blind head has been fully formed and is in clamping engagement with the blind side of the workpiece. Now as the relative axial force applied between the pin 14a and sleeve 12a increases a force of preselected magnitude is reached at which the pin 14a is fractured at the breakneck groove 60a and the pull groove portion 42a is removed. This then completes the installation. At the same time the secondary lock formed by the sleeve material which has flowed into the relief grooves 70a assists the primary lock by the sleeve material in the lock pocket 54a to resist loosening of the pin 14a and sleeve 12a to thereby improve the static and fatigue strength of the fastened joint.

The sleeve 12a and pin 14a can be made of the same materials noted for the sleeve 12 and pin 14. Thus, in view of the substantial identify of the pin 14a and sleeve 12a with the pin 14 and sleeve 12 as noted and the description of the only significant differences, a detailed description of the similar components has been omitted for purposes of simplicity.

While it will be apparent that the preferred embodiments of the invention disclosed are well calculated to fulfill the objects above stated, it will be appreciated that the invention is susceptible to modification, variation and change without departing from the proper scope or fair meaning of the invention.

What is claimed is:

1. A blind fastener for securing a plurality of workpieces having aligned workpiece bores comprising:

a hollow sleeve having a through bore,

said sleeve having a sleeve shank and an enlarged sleeve head at one end with said sleeve shank adapted to be located in the workpiece bores with a predetermined clearance,

a pin,

said pin having a pin shank and an enlarged pin head, said pin shank adapted to be located within said bore of said sleeve with said pin head located at the end of said sleeve shank opposite said sleeve head,

said through bore of said sleeve having an expansion bore portion in said sleeve shank and a reduced diameter bore portion proximate thereto and defining a radially inwardly extending sleeve stop shoulder at the juncture of said enlarged and reduced bore portions,

said reduced diameter bore portion located generally in said sleeve head,

said pin shank having an increased diameter expander pin portion having a diameter greater than the diameter of said expansion bore portion to provide a preselected interference,

said pin having a pin stop shoulder portion adjacent said expander pin portion,

a lock groove located proximate said pin stop shoulder,

said pin head adapted to engage said sleeve shank portion and to deform the same to form a blind head opposite said sleeve head in response to a relative axial force applied between said pin and said sleeve,

said pin stop shoulder adapted to engage said sleeve stop shoulder,

said pin stop shoulder and said sleeve stop shoulder having engaging surface means for directing the material of said sleeve stop shoulder substantially radially inwardly into said lock groove to lock said pin and said sleeve together and to finally form a stop surface on said sleeve for stopping axial movement of said pin through said sleeve,

said expander pin portion having a grooved section with a plurality of axially extending relief grooves circumferentially separated by expander segments, said expander segments defining a generally uniform circular outer surface, said expander segments and said relief grooves being generally of the same circumferential width, said expander pin portion adapted to be moved into said expansion bore portion to expand it radially outwardly to fill the clearance between said sleeve shank and the workpiece bores with said relief grooves receiving excess material of said expansion bore portion after filling of the workpiece bores.

2. The fastener of claim 1 with said sleeve stop shoulder defining a volume sufficient to generally fill the volume defined by said lock groove.

3. The fastener of claim 1 with said relief grooves forming a secondary lock between said pin and said sleeve by the excess material of said expansion bore portion flowing into said relief grooves.

4. The fastener of claim 3 with said sleeve stop shoulder defining a volume sufficient to generally fill the volume defined by said lock groove to form a primary lock to hold said pin and sleeve together, said relief grooves forming a secondary lock between said pin and said sleeve by the excess material of said expansion bore portion flowing into said relief grooves.

5. The fastener of claim 1 with said circumferential width of said expander segments and of said relief grooves being around 16°.

6. The fastener of claim 1 with said sleeve shank being formed with a preselected hardness and having an intermediate portion formed with a gradient of reduced hardness,

said intermediate portion adapted to extend past the end surface of the adjacent workpiece and to deform radially outwardly to form a blind head of bulbed configuration in response to the relative axial force applied to said sleeve shank by said pin head with said bulbed blind head formed to the end surface of the adjacent workpiece to clamp the workpieces together.

7. The blind fastener of claim 1 with the workpiece bores having at least a section defined by axially straight portions and with said fastener adapted to secure workpieces having a determinable total thickness,

said grooved section having a preselected axial length to substantially coincide with the axially straight portions of the workpiece bores and to extend partially past the end surface of the adjacent workpiece whereby said relief grooves are located a limited distance past the workpiece bores to provide additional volume to receive excess material of said sleeve shank from the radial expansion in filling of the axially straight portions of the workpiece bores.

8. A blind fastener for securing a plurality of workpieces having aligned workpiece bores comprising:

a hollow sleeve having a through bore,

said sleeve having a sleeve shank and an enlarged sleeve head at one end with said sleeve shank adapted to be located in the workpiece bores with a predetermined clearance,

a pin,

said pin having a pin shank and an enlarged pin head, said pin shank adapted to be located within said bore of said sleeve with said pin head located at the end of said sleeve shank opposite said sleeve head,

said through bore of said sleeve having an expansion bore portion in said sleeve shank and a reduced diameter bore portion proximate thereto and defining a radially inwardly extending sleeve stop shoulder at the juncture of said enlarged and reduced bore portions,

said reduced diameter bore portion located generally in said sleeve head,

said pin shank having an increased diameter expander pin portion having a diameter greater than the diameter of said expansion bore portion to provide a preselected interference,

said pin having a pin stop shoulder portion adjacent said expander pin portion,

a lock groove located proximate said pin stop shoulder,

said pin head adapted to engage said sleeve shank portion and to deform the same to form a blind head opposite said sleeve head in response to a relative axial force applied between said pin and said sleeve,

said pin stop shoulder adapted to engage said sleeve stop shoulder,

said pin stop shoulder and said sleeve stop shoulder having engaging surface means for directing the material of said sleeve stop shoulder substantially radially inwardly into said lock groove to lock said pin and said sleeve together and to finally form a stop surface on said sleeve for stopping axial movement of said pin through said sleeve,

said expander pin portion having a grooved section with a plurality of axially extending relief grooves circumferentially separated by expander segments, said expander segments defining a generally uniform circular outer surface, said expander segments and said relief grooves being generally of the same circumferential width, said expander pin portion adapted to be moved into said expansion bore portion to expand it radially outwardly to fill the clearance between said sleeve shank and the workpiece bores with said relief grooves receiving excess material of said expansion bore portion after filling of the workpiece bores,

said pin having a pull portion adapted to be gripped by a tool for applying said relative axial force between said pin and said sleeve,

a breakneck groove connecting said pull portion to said pin shank portion and being adapted to fracture at a preselected magnitude of said relative axial force, said breakneck groove connected with said annular lock groove by a generally uniform section of said pin shank portion,

said sleeve stop shoulder located generally within the confines of said enlarged sleeve head whereby radial expansion of said sleeve is inhibited as said sleeve stop shoulder is deformed into said lock groove,

said sleeve head having a preselected axial length,

said breakneck groove being located a predetermined maximum axial distance from said lock groove whereby distortion of said lock groove in response to application of said preselected magnitude of said axial force is inhibited,

said maximum axial distance being generally equal to said preselected axial length of said sleeve head, for finally locating said lock groove and said breakneck groove generally within the confines of said sleeve head.

9. The fastener of claim 8 with said sleeve stop shoulder defining a volume sufficient to generally fill the volume defined by said lock groove.

10. The fastener of claim 8 with said relief grooves forming a secondary lock between said pin and said sleeve by the excess material of said expansion bore portion flowing into said relief grooves.

11. The fastener of claim 8 with said sleeve stop shoulder defining a volume sufficient to generally fill the volume defined by said lock groove to form a primary lock to hold said pin and sleeve together, said relief grooves forming a secondary lock between said pin and said sleeve by the excess material of said expansion bore portion flowing into said relief grooves.

12. The fastener of claim 8 with said circumferential width of said expander segments and of said relief grooves being around 16°.

13. The fastener of claim 8 with said sleeve shank being formed with a preselected hardness and having an intermediate portion formed with a gradient of reduced hardness,

said intermediate portion adapted to extend past the end surface of the adjacent workpiece and to deform radially outwardly to form a blind head of bulbed configuration in response to the relative axial force applied to said sleeve shank by said pin head with said bulbed blind head formed to the end surface of the adjacent workpiece to clamp the workpieces together.

14. The blind fastener of claim 8 with the workpiece bores having at least a section defined by axially straight portions and with said fastener adapted to secure workpieces having a determinable total thickness,

said grooved section having a preselected axial length to substantially coincide with the axially straight portions of the workpiece bores and to extend partially past the end surface of the adjacent workpiece whereby said relief grooves are located a limited distance past the workpiece bores to provide additional volume to receive excess material of said sleeve shank from the radial expansion in filling of the axially straight portions of the workpiece bores.

15. A blind fastener for securing a plurality of workpieces having aligned workpiece bores comprising:

a hollow sleeve having a through bore,

said sleeve having a sleeve shank and an enlarged sleeve head at one end with said sleeve shank adapted to be located in the workpiece bores with a predetermined clearance,

a pin,

said pin having a pin shank and an enlarged pin head, said pin shank adapted to be located within said bore of said sleeve with said pin head located at the end of said sleeve shank opposite said sleeve head,

said through bore of said sleeve having an expansion bore portion in said sleeve shank and a reduced diameter bore portion proximate thereto and defining a radially inwardly extending sleeve stop shoulder at the juncture of said enlarged and reduced bore portions,

said reduced diameter bore portion located generally in said sleeve head,

said pin shank having an increased diameter expander pin portion having a diameter greater than the diameter of said expansion bore portion to provide a preselected interference,

said pin having a pin stop shoulder portion adjacent said expander pin portion,

a lock groove located proximate said pin stop shoulder,

said pin head adapted to engage said sleeve shank portion and to deform the same to form a blind head opposite said sleeve head in response to a relative axial force applied between said pin and said sleeve,

said pin stop shoulder adapted to engage said sleeve stop shoulder,

said pin stop shoulder and said sleeve stop shoulder having engaging surface means for directing the material of said sleeve stop shoulder substantially radially inwardly into said lock groove to lock said pin and said sleeve together and to finally form a stop surface on said sleeve for stopping axial movement of said pin through said sleeve,

said expander pin portion having a grooved section with a plurality of axially extending relief grooves circumferentially separated by expander segments, said expander segments defining a generally uniform circular outer surface, said expander segments and said relief grooves being generally of the same circumferential width, said expander pin portion adapted to be moved into said expansion bore portion to expand it radially outwardly to fill the clearance between said sleeve shank and the workpiece bores with said relief grooves

receiving excess material of said expansion bore portion after filling of the workpiece bores,

said expander pin portion having a leading end terminating in a generally smooth tapered lead-in segment to facilitate initial movement into and initial radial expansion of said expansion bore portion of said sleeve shank,

said expander pin portion having a lead expander segment with a generally uniform, continuous circular outer surface connecting said tapered lead-in segment to said grooved section,

said outer surface of said lead expander segment being of substantially the same diameter as said expander segments and being of a limited axial length to facilitate radial expansion of said expansion bore portion and flow of excess material of said sleeve shank into said relief grooves.

16. The fastener of claim **15** with said sleeve stop shoulder defining a volume sufficient to generally fill the volume defined by said lock groove.

17. The fastener of claim **15** with said relief grooves forming a secondary lock between said pin and said sleeve by the excess material of said expansion bore portion flowing into said relief grooves.

18. The fastener of claim **15** with said sleeve stop shoulder defining a volume sufficient to generally fill the volume defined by said lock groove to form a primary lock to hold said pin and sleeve together, said relief grooves forming a secondary lock between said pin and said sleeve by the excess material of said expansion bore portion flowing into said relief grooves.

19. The fastener of claim **15** with said circumferential width of said expander segments and of said relief grooves being around 16°.

20. The fastener of claim **15** with said sleeve shank being formed with a preselected hardness and having an intermediate portion formed with a gradient of reduced hardness,

said intermediate portion adapted to extend past the end surface of the adjacent workpiece and to deform radially outwardly to form a blind head of bulbed configuration in response to the relative axial force applied to said sleeve shank by said pin head with said bulbed blind head formed to the end surface of the adjacent workpiece to clamp the workpieces together.

21. The blind fastener of claim **15** with the workpiece bores having at least a section defined by axially straight portions and with said fastener adapted to secure workpieces having a determinable total thickness,

said grooved section having a preselected axial length to substantially coincide with the axially straight portions of the workpiece bores and to extend partially past the end surface of the adjacent workpiece whereby said relief grooves are located a limited distance past the workpiece bores to provide additional volume to receive excess material of said sleeve shank from the radial expansion in filling of the axially straight portions of the workpiece bores.

22. A blind fastener for securing a plurality of workpieces having aligned workpiece bores with the workpiece bores having at least a section defined by axially straight portions, said blind fastener comprising:

a hollow sleeve having a through bore,

said sleeve having a sleeve shank and an enlarged sleeve head at one end with said sleeve shank adapted to be located in the axially straight portions of the workpiece bores with a predetermined clearance,

a pin,

said pin having a pin shank and an enlarged pin head, said pin shank adapted to be located within said bore of said sleeve with said pin head located at the end of said sleeve shank opposite said sleeve head,

said through bore of said sleeve having an expansion bore portion in said sleeve shank and a reduced diameter bore portion proximate thereto and defining a radially inwardly extending sleeve stop shoulder at the juncture of said enlarged and reduced bore portions,

said reduced diameter bore portion located generally in said sleeve head,

said pin shank having an increased diameter expander pin portion having a diameter greater than the diameter of said expansion bore portion to provide a preselected interference,

said pin having a pin stop shoulder portion adjacent said expander pin portion,

a lock groove located proximate said pin stop shoulder,

said pin head adapted to engage said sleeve shank portion and to deform the same to form a blind head opposite said sleeve head in response to a relative axial force applied between said pin and said sleeve,

said pin stop shoulder adapted to engage said sleeve stop shoulder,

said pin stop shoulder and said sleeve stop shoulder having engaging surface means for directing the material of said sleeve stop shoulder substantially radially inwardly into said lock groove to lock said pin and said sleeve together and to finally form a stop surface on said sleeve for stopping axial movement of said pin through said sleeve,

said expander pin portion having a grooved section with a plurality of axially extending relief grooves circumferentially separated by expander segments, said expander segments defining a generally uniform circular outer surface, said expander segments and said relief grooves being generally of the same circumferential width, said expander pin portion adapted to be moved into said expansion bore portion to expand it radially outwardly to fill the clearance between said sleeve shank and the axially straight portions of the workpiece bores with said relief grooves receiving excess material of said expansion bore portion after filling of the axially straight portions of the workpiece bores,

said sleeve stop shoulder defining a volume sufficient to generally fill the volume defined by said lock groove to form a primary lock to hold said pin and sleeve together, said relief grooves forming a secondary lock between said pin and said sleeve by the excess material of said expansion bore portion flowing into said relief grooves,

said fastener adapted to secure workpieces having a determinable total thickness,

said grooved section having a preselected axial length to substantially coincide with the axially straight portions of the workpiece bores and to extend partially past the end surface of the adjacent workpiece whereby said relief grooves are located a limited distance past the workpiece bores to provide additional volume to receive excess material of said sleeve shank from the radial expansion in filling of the axially straight portions of the workpiece bores.

23. The fastener of claim **22** with said sleeve shank being formed with a preselected hardness and having an intermediate portion formed with a gradient of reduced hardness,

said intermediate portion adapted to extend past the end surface of the adjacent workpiece and to deform radially outwardly to form a blind head of bulbed configuration in response to the relative axial force applied to said sleeve shank by said pin head with said bulbed blind head formed to the end surface of the adjacent workpiece to clamp the workpieces together.

24. The fastener of claim **23** with said pin having a pull portion adapted to be gripped by a tool for applying said axial force, a breakneck groove connecting said pull portion to said pin shank portion and being adapted to fracture at a preselected magnitude of said axial force, said breakneck groove connected with said annular lock groove by a generally uniform section of said pin shank portion,

said sleeve stop shoulder located generally within the confines of said enlarged sleeve head whereby radial expansion of said sleeve is inhibited as said sleeve stop shoulder is deformed into said lock groove,

said sleeve head having a preselected axial length,

said breakneck groove being located a predetermined maximum axial distance from said lock groove whereby distortion of said lock groove in response to application of said preselected magnitude of said axial force is inhibited,

said maximum axial distance being generally equal to said preselected axial length of said sleeve head, for finally locating said lock groove and said breakneck groove generally within the confines of said sleeve head.

25. A blind fastener for securing a plurality of workpieces having aligned workpiece bores comprising:

a hollow sleeve having a through bore,

said sleeve having a sleeve shank and an enlarged sleeve head at one end with said sleeve shank adapted to be located in the workpiece bores with a predetermined clearance,

a pin,

said pin having a pin shank and an enlarged pin head, said pin shank adapted to be located within said bore of said sleeve with said pin head located at the end of said sleeve shank opposite said sleeve head,

said through bore of said sleeve having an expansion bore portion in said sleeve shank and a reduced diameter bore portion proximate thereto and defining a radially inwardly extending sleeve stop shoulder at the juncture of said enlarged and reduced bore portions,

said reduced diameter bore portion located generally in said sleeve head,

said pin shank having an increased diameter expander pin portion having a diameter greater than the diameter of said expansion bore portion to provide a preselected interference,

said pin having a pin stop shoulder portion adjacent said expander pin portion,

a lock groove located proximate said pin stop shoulder,

said pin head adapted to engage said sleeve shank portion and to deform the same to form a blind head opposite said sleeve head in response to a relative axial force applied between said pin and said sleeve,

said pin stop shoulder adapted to engage said sleeve stop shoulder,

said pin stop shoulder and said sleeve stop shoulder having engaging surface means for directing the material of said sleeve stop shoulder substantially radially inwardly into said lock groove to lock said pin and said sleeve together and to finally form a stop surface on said sleeve for stopping axial movement of said pin through said sleeve,

said expander pin portion having a grooved section with a plurality of axially extending relief grooves circumferentially separated by expander segments, said expander segments defining a generally uniform circular outer surface, said expander segments and said relief grooves being generally of the same circumferential width, said expander pin portion adapted to be moved into said expansion bore portion to expand it radially outwardly to fill the clearance between said sleeve shank and the workpiece bores with said relief grooves receiving excess material of said expansion bore portion after filling of the workpiece bores,

said relief grooves being of a radially shallow depth and having a generally arcuate contour smoothly blending with said generally circular outer surface of said expander segments,

said relief grooves forming a secondary lock between said pin and said sleeve by the excess material of said expansion bore portion flowing into said relief grooves.

26. The fastener of claim **25** with said radial depth of said relief grooves being between around 2% to around 2.5% of the diameter of said expander pin portion.

27. The fastener of claim **25** with said expander segments having a preselected radius and with the arcuate contour of said relief grooves being generally at a radius of around one third of the radius of said expander segments.

28. The fastener of claim **25** with said radial depth of said relief grooves being between around 2% to around 2.5% of the diameter of said expander pin portion,

said expander segments having a preselected radius and with the arcuate contour of said relief grooves being generally at a radius of around one third of the radius of said expander segments,

said relief grooves forming a secondary lock between said pin and said sleeve by the excess material of said expansion bore portion flowing into said relief grooves.

29. The fastener of claim **25** with said sleeve shank being formed with a preselected hardness and having an intermediate portion formed with a gradient of reduced hardness,

said intermediate portion adapted to extend past the end surface of the adjacent workpiece and to deform radially outwardly to form a blind head of bulbed configuration in response to the relative axial force applied to said sleeve shank by said pin head with said bulbed blind head formed to the end surface of the adjacent workpiece to clamp the workpieces together,

said pin constructed of a material with a hardness of at least around 44 Rc and with said sleeve having an overall hardness of around 96 Rb and with the hardness of said intermediate portion being reduced to around 70 Rb.

30. A blind fastener for securing a plurality of workpieces having aligned workpiece bores comprising:

a hollow sleeve having a through bore,

said sleeve having a sleeve shank and an enlarged sleeve head at one end with said sleeve shank adapted to be located in the workpiece bores with a predetermined clearance,

a pin,

said pin having a pin shank and an enlarged pin head, said pin shank adapted to be located within said bore of said sleeve with said pin head located at the end of said sleeve shank opposite said sleeve head,

said through bore of said sleeve having an expansion bore portion in said sleeve shank and a reduced diameter bore portion proximate thereto and defining a radially inwardly extending sleeve stop shoulder at the juncture of said enlarged and reduced bore portions,

said reduced diameter bore portion located generally in said sleeve head,

said pin shank having an increased diameter expander pin portion having a diameter greater than the diameter of said expansion bore portion to provide a preselected interference,

said pin having a pin stop shoulder portion adjacent said expander pin portion,

a lock groove located proximate said pin stop shoulder,

said pin head adapted to engage said sleeve shank portion and to deform the same to form a blind head opposite said sleeve head in response to a relative axial force applied between said pin and said sleeve,

said pin stop shoulder adapted to engage said sleeve stop shoulder,

said pin stop shoulder and said sleeve stop shoulder having engaging surface means for directing the material of said sleeve stop shoulder substantially radially inwardly into said lock groove to lock said pin and said sleeve together and to finally form a stop surface on said sleeve for stopping axial movement of said pin through said sleeve,

said expander pin portion having a grooved section with a plurality of axially extending relief grooves circumferentially separated by expander segments, said expander segments defining a generally uniform circular outer surface, said expander segments and said relief grooves being generally of the same circumferential width, said expander pin portion adapted to be moved into said expansion bore portion to expand it radially outwardly to fill the clearance between said sleeve shank and the workpiece bores with said relief grooves receiving excess material of said expansion bore portion after filling of the workpiece bores,

said sleeve shank having an enlarged counterbore at its open end connected to said expansion bore portion by a locating shoulder,

said expander pin portion adapted to be moved into said counterbore with a slight interference fit generally up to said locating shoulder for pre-assembly prior to installation.

* * * * *

US006257814B1

(12) United States Patent
Müller

(10) Patent No.: US 6,257,814 B1
(45) Date of Patent: Jul. 10, 2001

(54) SELF-ATTACHING FASTENER, METHOD OF FORMING SAME AND METHOD OF ATTACHMENT

(75) Inventor: Rudolf R. M. Müller, Frankfurt (DE)

(73) Assignee: Profil Verbindungstechnik & Co. (DE)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: 09/149,626

(22) Filed: Sep. 8, 1998

Related U.S. Application Data

(63) Continuation of application No. 08/773,526, filed on Dec. 23, 1996, which is a continuation-in-part of application No. 08/698,870, filed on Aug. 16, 1996, now Pat. No. 5,782,594.

(30) **Foreign Application Priority Data**

Aug. 18, 1995 (DE) 195 30 466

(51) **Int. Cl.**[7] **F16B 39/00**

(52) **U.S. Cl.** **411/176**; 411/179; 411/180; 411/181

(58) **Field of Search** 411/179, 180, 411/181, 176; 29/432, 432.1, 525, 525.01

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,253,631 *	5/1966	Reusser	411/179
3,282,315	11/1966	Zahodiakin .	
3,282,317	11/1966	Zahodiakin	411/176
3,299,500	1/1967	Double .	
3,724,520	4/1973	Ladouceur et al. .	
3,810,291	5/1974	Ladouceur .	
3,926,236	12/1975	Pouch et al. .	
4,708,556	11/1987	Pamer et al. .	
5,531,552 *	7/1996	Takahashi et al.	411/180
5,549,430	8/1996	Takahashi et al. .	
5,782,594	7/1998	Muller .	

FOREIGN PATENT DOCUMENTS

2227039	12/1972	(DE) .
2229499	7/1976	(DE) .
3019070A1	5/1980	(DE) .
3314487A1	4/1983	(DE) .
2441977	4/1985	(DE) .
3524306A1	7/1985	(DE) .

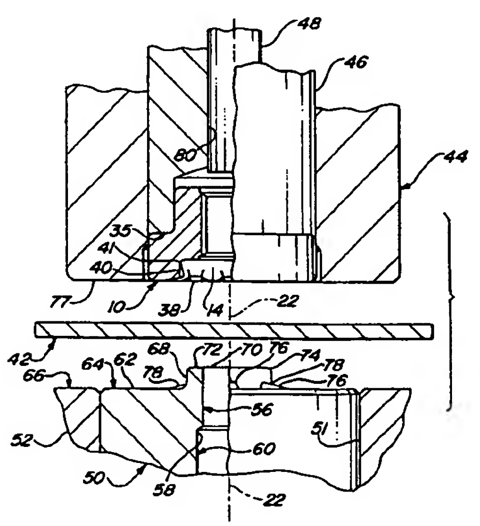
* cited by examiner

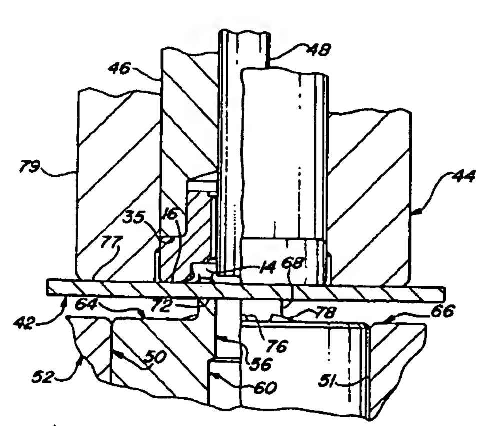
Primary Examiner—Lynne H. Browne
Assistant Examiner—Fredrick Conley
(74) *Attorney, Agent, or Firm*—Howard & Howard

(57) **ABSTRACT**

A fastener, for example a nut element, for attachment to a plate-like component with an end face of the fastener having a recess within a raised contact surface and a plurality of projections and undercuts are provided in a sidewall of the recess. The base surface of the recess extends up to the bore of the fastener without the presence of a pilot portion and a plurality of recesses are provided in the contact surface for resisting rotation. The die button which serves for the attachment of the fastener to a plate-like component has a hole-forming punch projection which has a plurality of noses distributed around the periphery in the region of the transition to the planar surface of the die button. On attachment of the hollow element to a plate-like component in a press, the sheet metal part is perforated by a hole punch and is molded in form-locked manner by the die button, in particular by its hole-forming punch projection, into the recess of the hollow element. The connection as generated is particularly suitable for sheet metal parts which are subjected to changing loads in operation, and has a high resistance to twist-out and push-out.

5 Claims, 10 Drawing Sheets





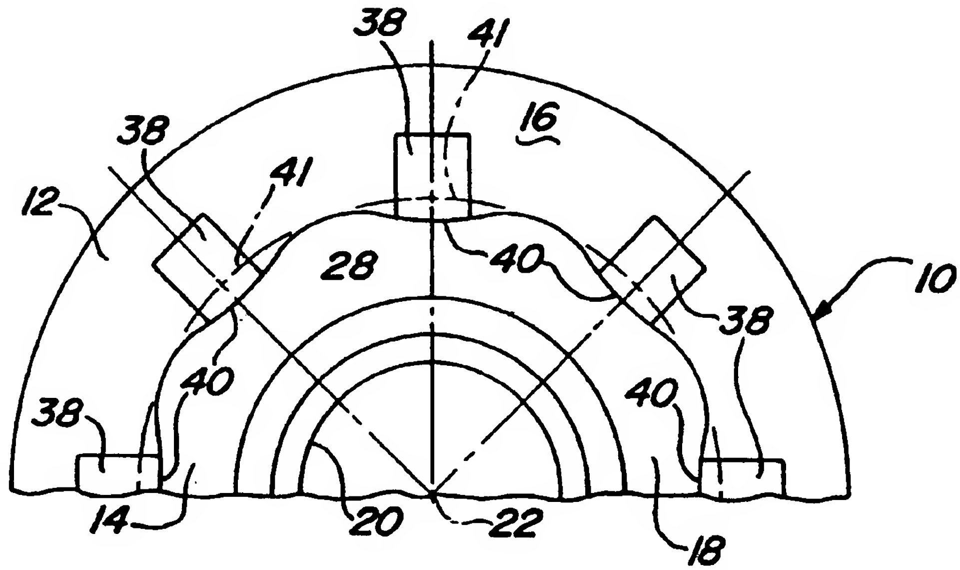

38
41
16
38
41
12
28
40
10
38
38
40
40
14
20
22
18

Fig-1

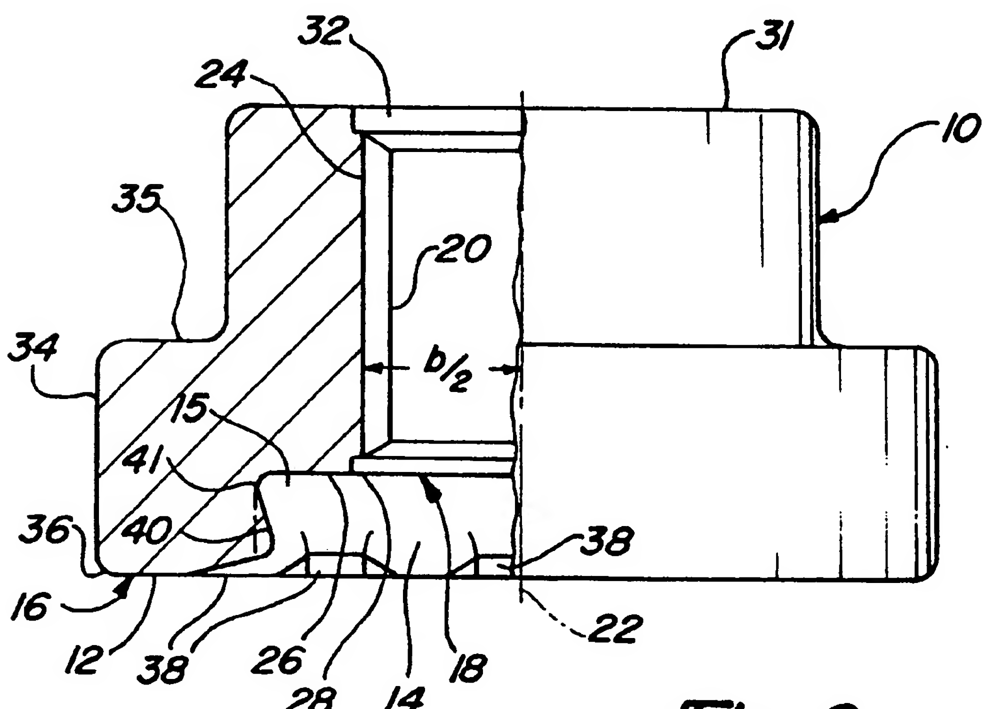

32
31
24
10
35
20
34
b/2
15
41
36
40
38
16
22
12
38
26
28
14
18

Fig-2

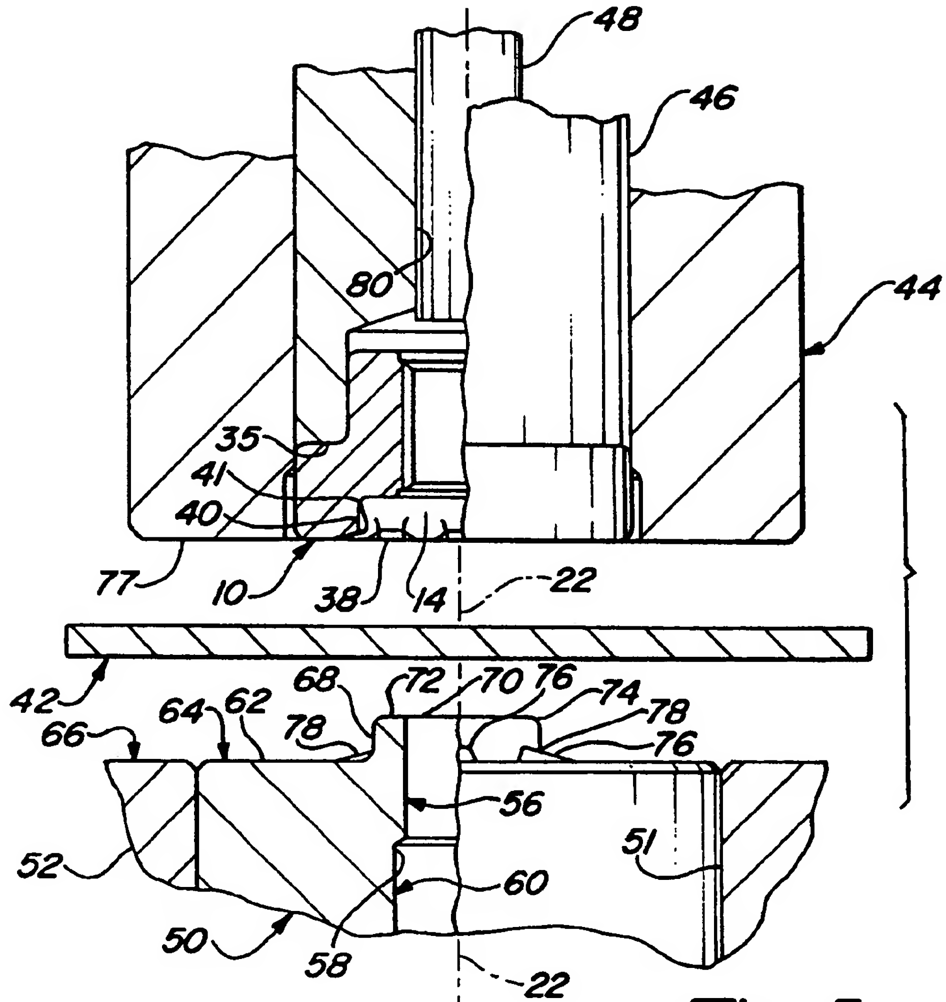

48
46
44
80
35
41
40
77
10
38
14
22
42
66
64
62
68
78
72
70
76
74
78
76
56
52
51
60
50
58
22

Fig - 3

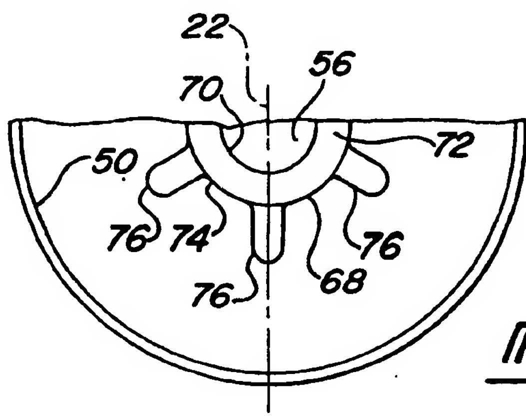

22
70
56
72
50
76
74
76
76
68

Fig - 3A

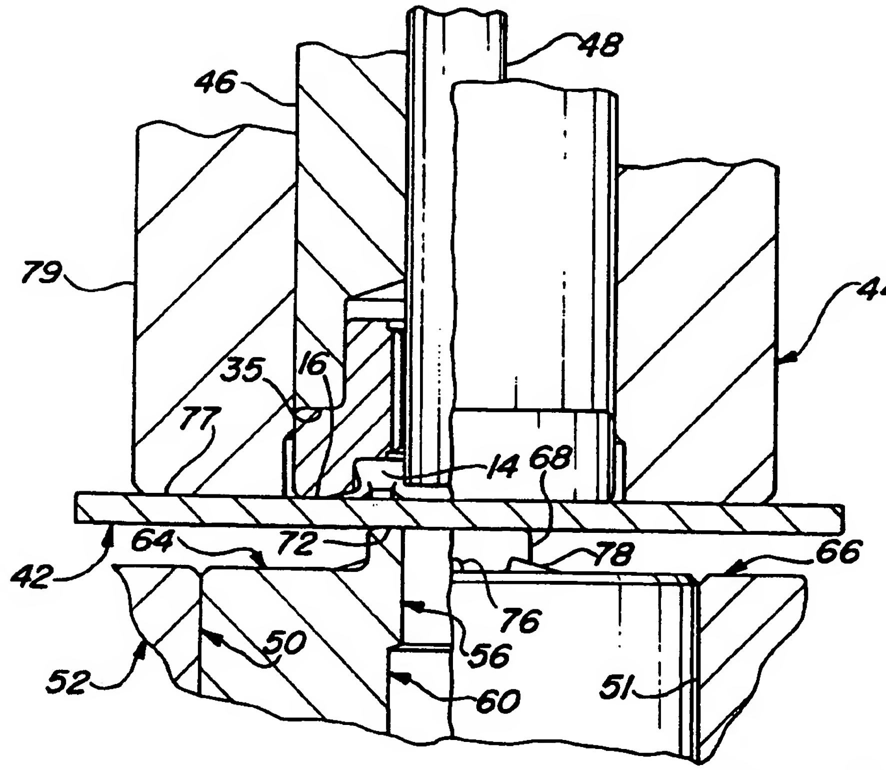

48
46
79
44
35
16
77
14
68
42
64
72
78
66
76
50
56
52
60
51

Fig - 4

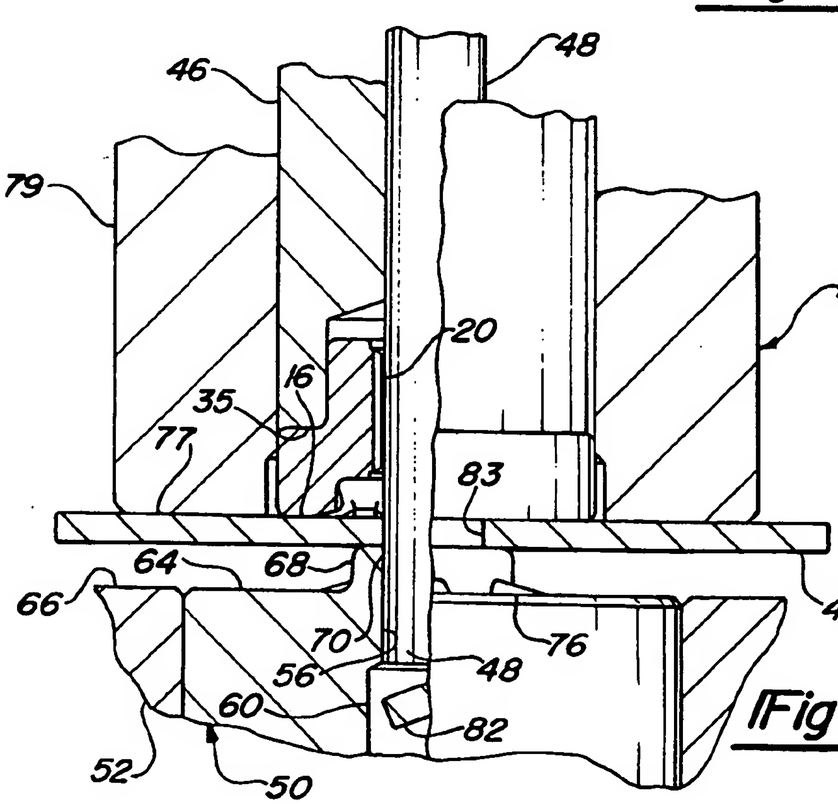
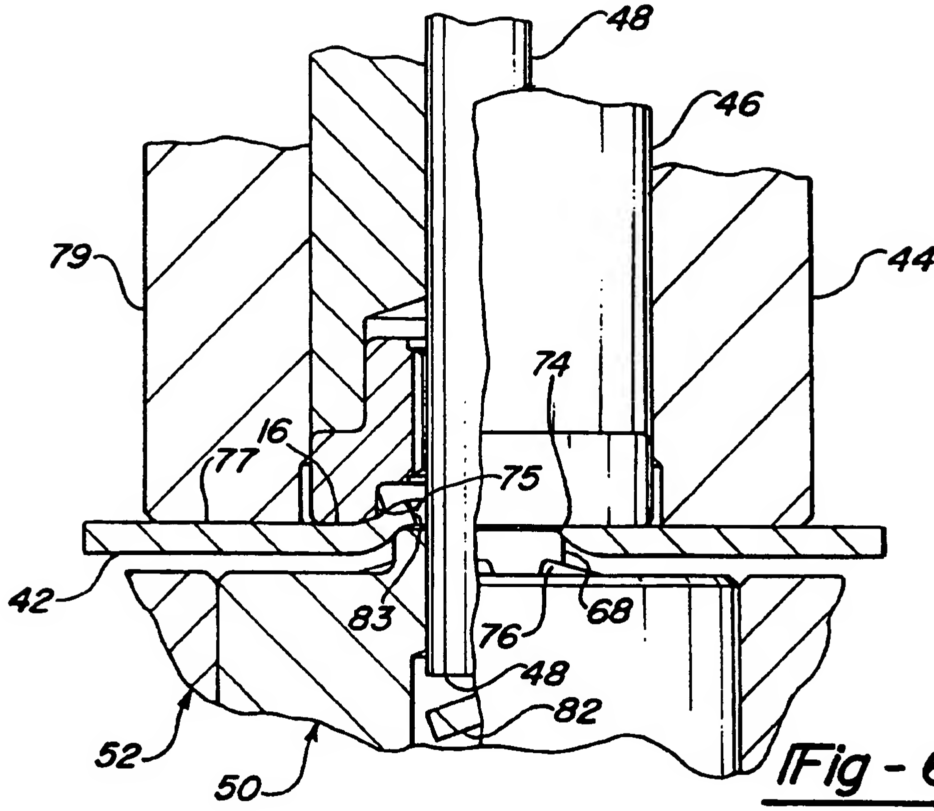
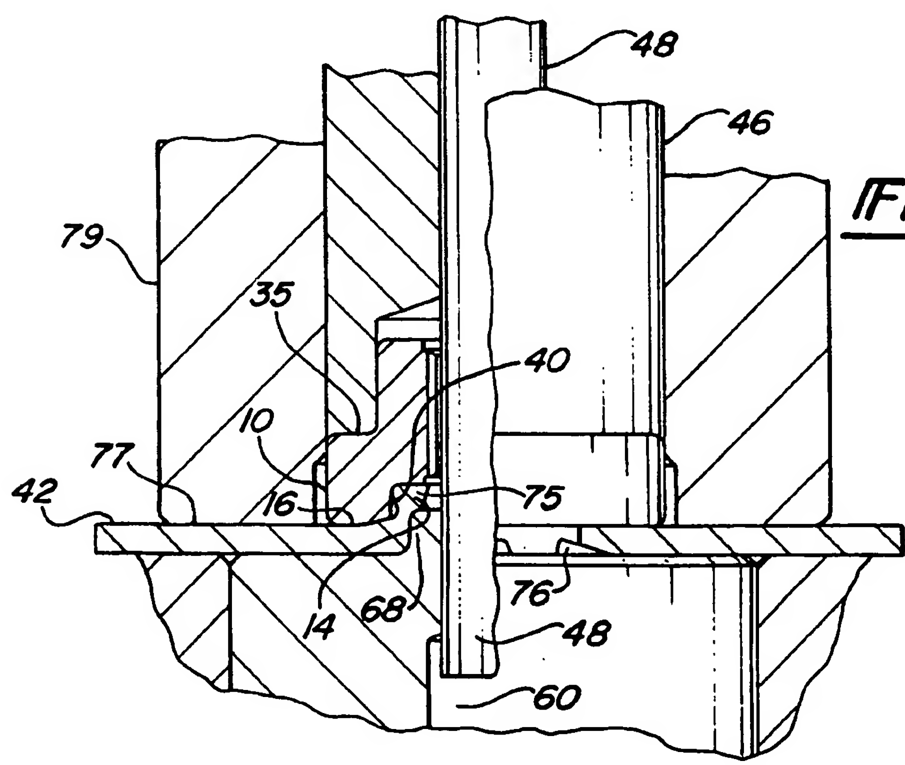

48
46
79
44
20
16
35
77
83
64
68
66
42
70
76
56
48
60
82
52
50

Fig - 5



48
46
79
44
74
16
77
75
42
83
76
68
48
82
52
50

Fig - 6



48
46
79
35
40
10
77
42
16
75
14
68
76
48
60

Fig - 7

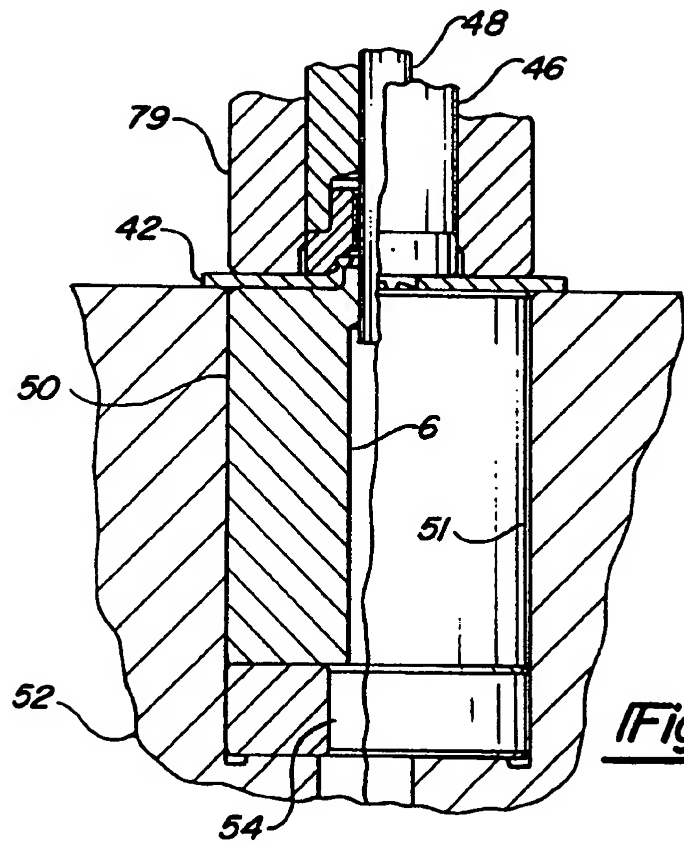


Fig-7A

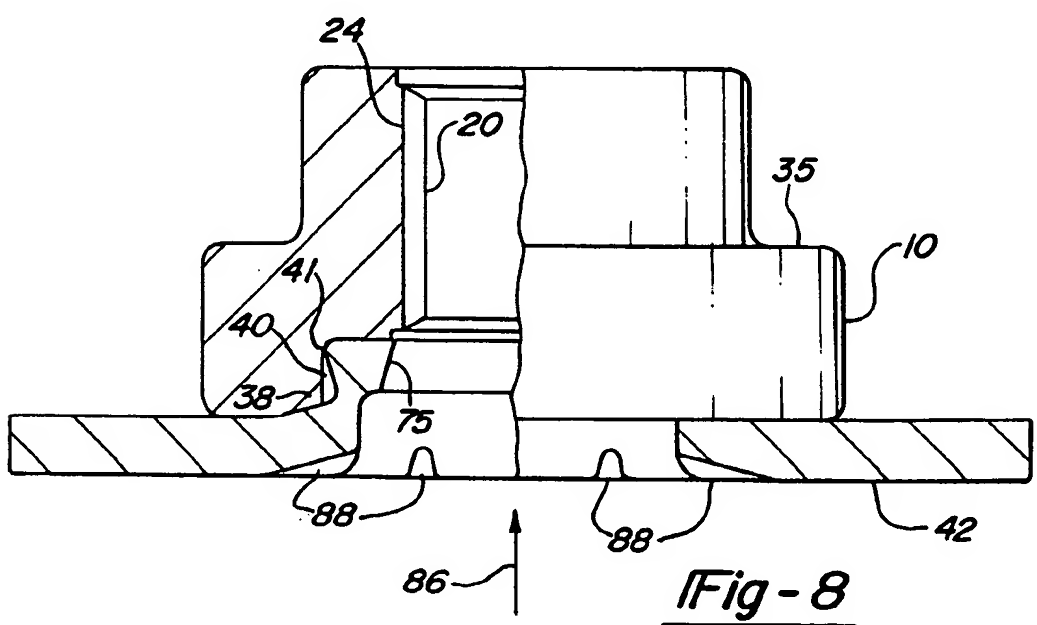


Fig-8

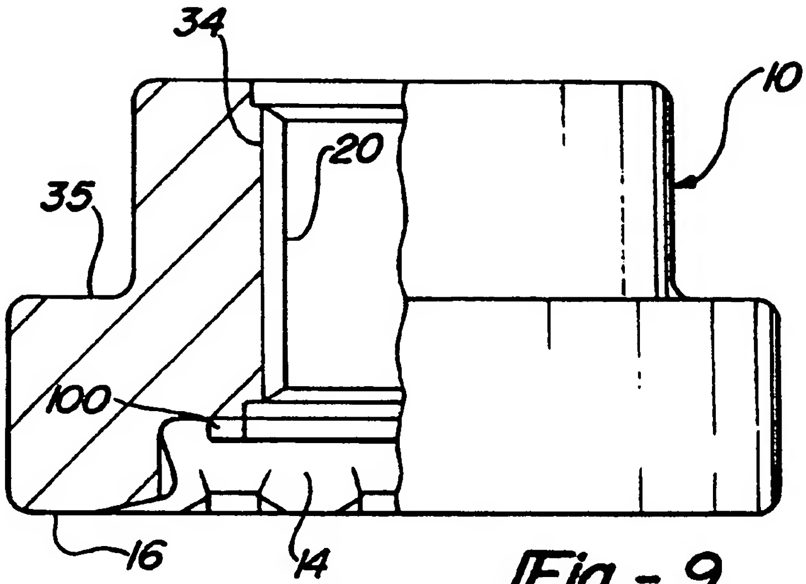


Fig - 9

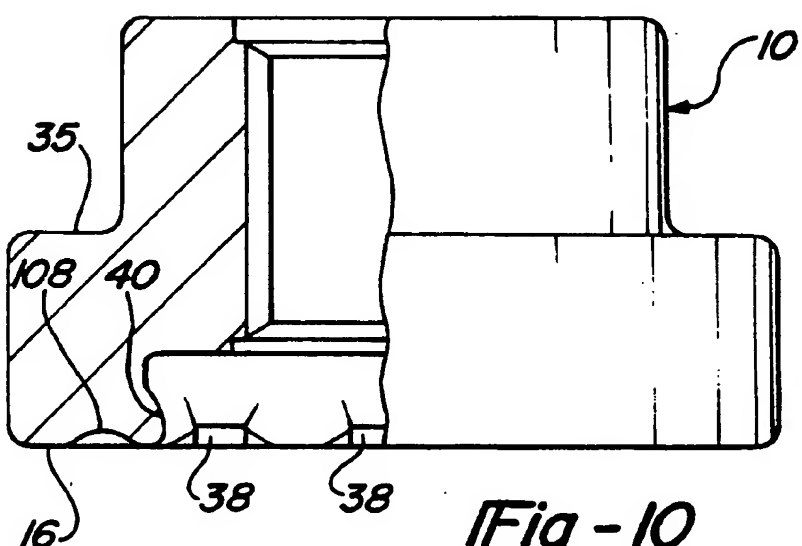


Fig - 10

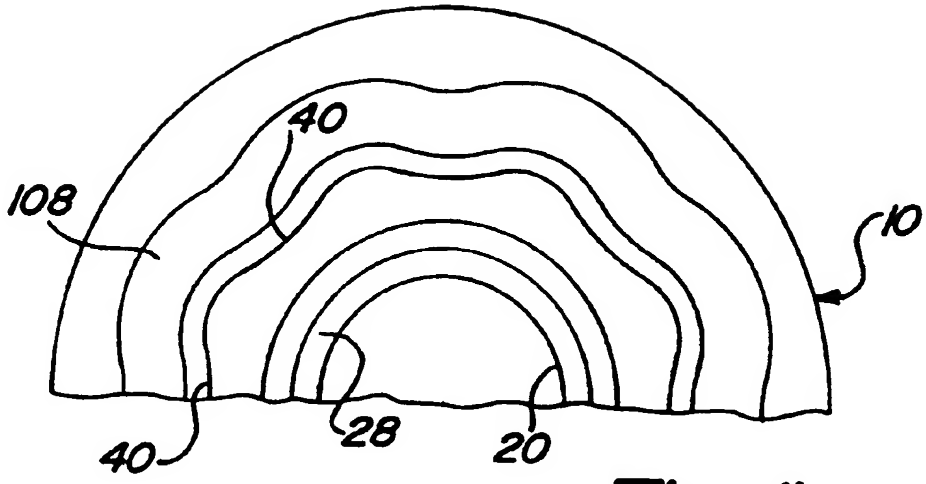


Fig - 11

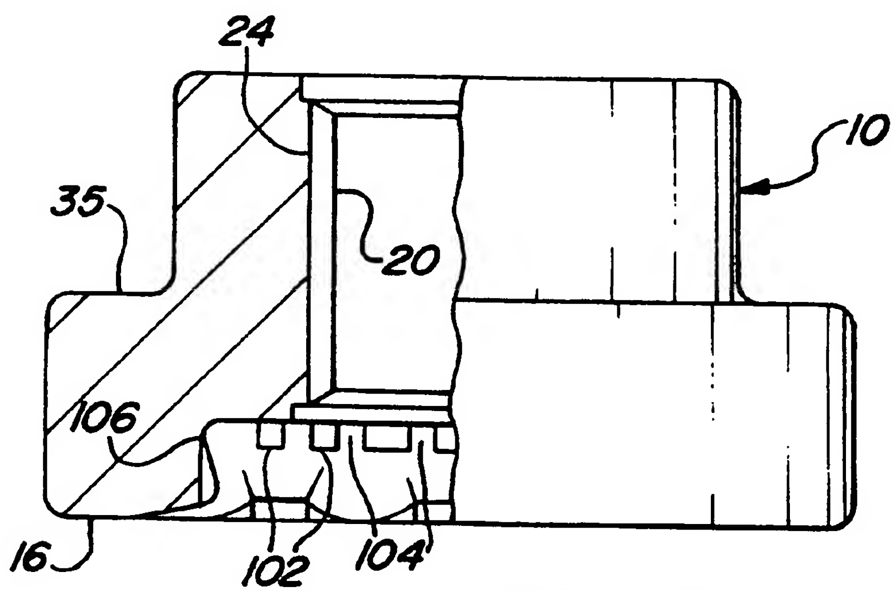


Fig - 12

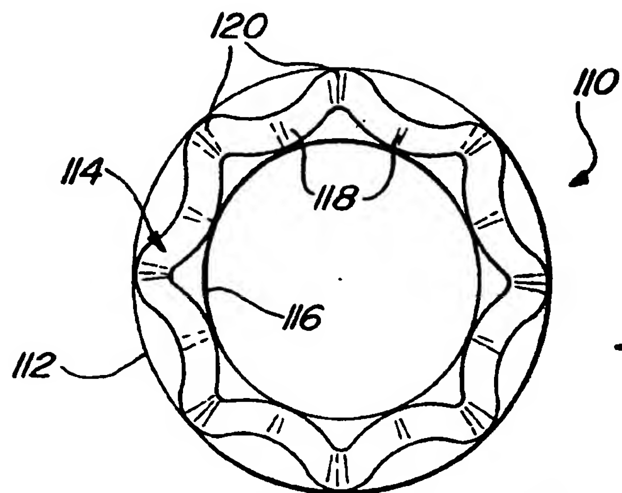


Fig-13

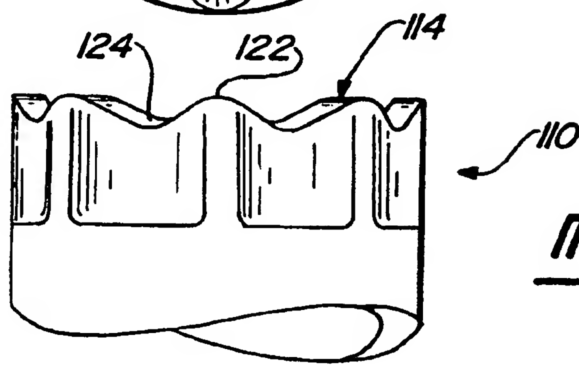


Fig-14

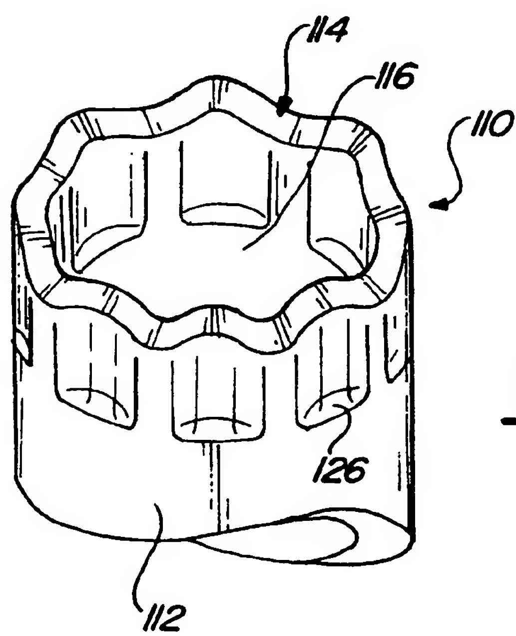


Fig-15

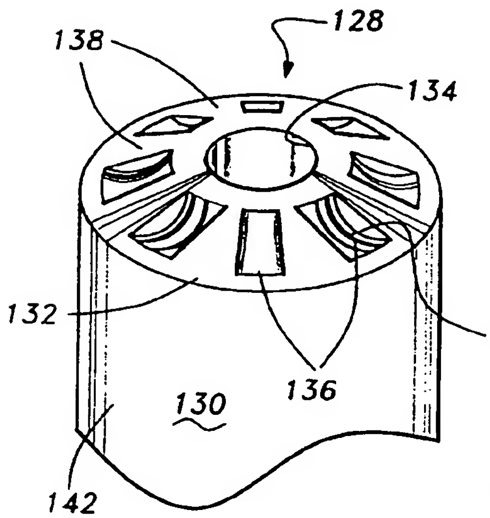


Fig-16

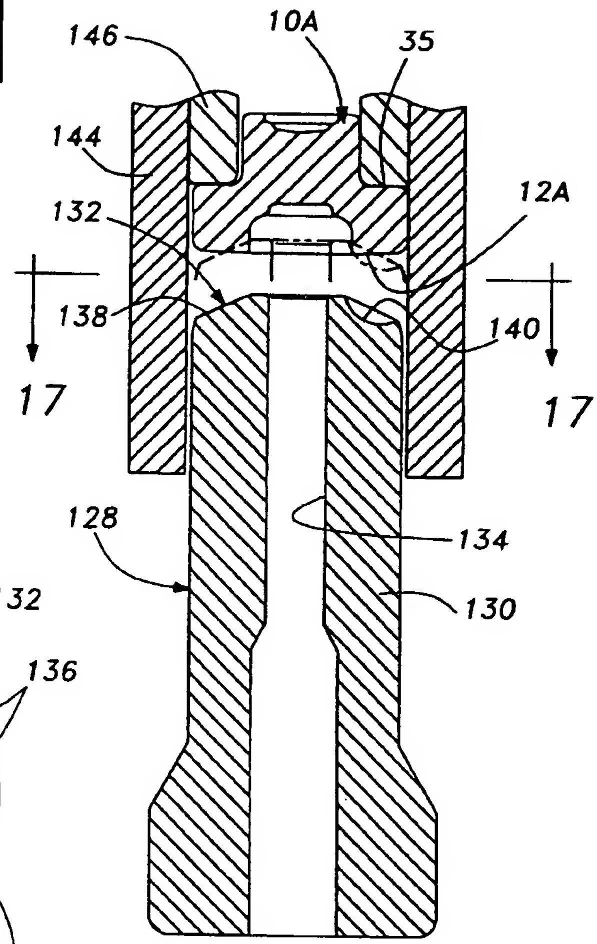


Fig-18

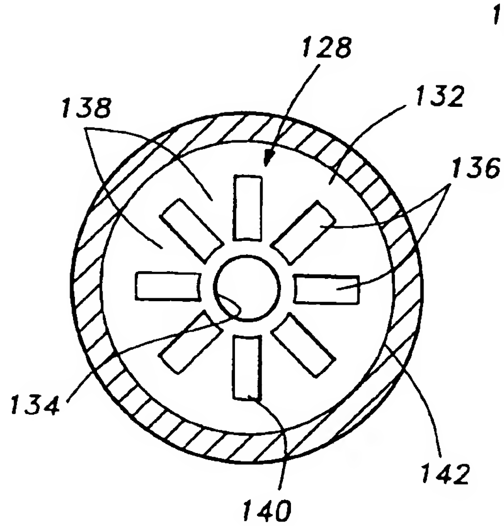


Fig-17

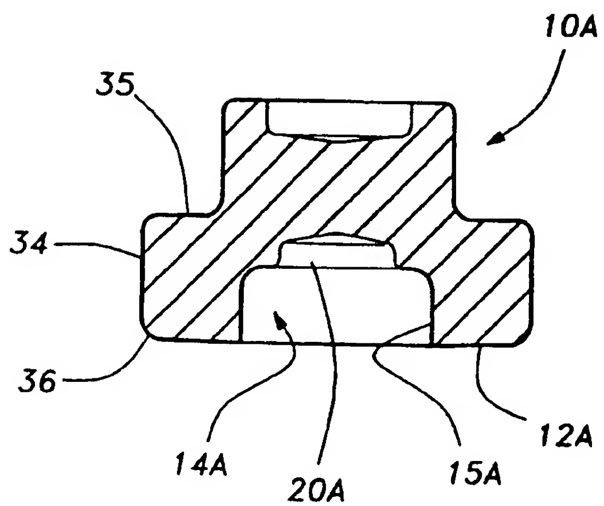


Fig- 19A

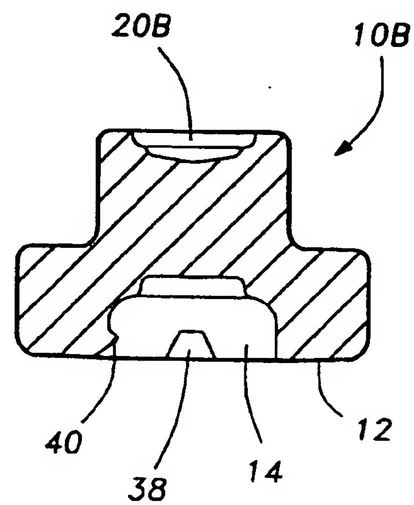


Fig- 19B

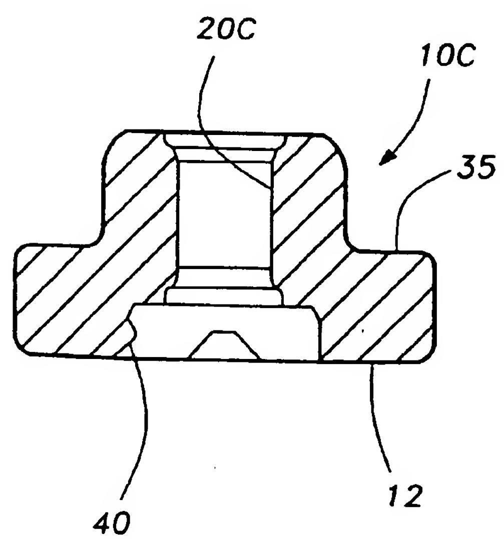


Fig- 19C

SELF-ATTACHING FASTENER, METHOD OF FORMING SAME AND METHOD OF ATTACHMENT

This is a continuation of co-pending application which U.S. Ser. No. 08/773,526 filed on Dec. 23, 1996,is a continuation-in-part application of U.S. Pat. application Ser. No. 08/698,870 filed Aug. 16, 1996 now U.S. Pat. No. 5,782,594 which claims priority to German Patent Application No. 19530466.7 filed on Aug. 18, 1995.

BACKGROUND

The present invention relates to self-attaching fasteners, a die button for use with such fasteners, a method of attaching such fasteners to a plate-like component, and the assembly which results after carrying out the method and the method of forming the improved self-attaching fasteners.

Fasteners of the general type having a hollow body or bore, such as for example internally threaded nuts are known from EP-A-0 553 822 A1 or from the corresponding US-A-5 340 251. Similar elements having hollow bodies are moreover known from US-A-3 234 987, from US-A-3 648 747 or from US-A-3 253 631.

All these known embodiments have a so-called pilot portion. That is to say that the groove or recess at the end face projecting toward the panel or part is restricted at the radially inner side by a projecting cylindrical pilot portion which extends at least substantially up to the end face.

Such fasteners are typically nut elements; however, for example they could have a cylindrical bore for receiving a spigot or the like. These fasteners offer relatively high security against rotation so that on screwing in a bolt element the fasteners remain firmly anchored to the component, and moreover have a relatively high resistance to push-out.

It has however been found that in operation with changing loads the fasteners sometimes tear out of the plate-like component which is normally made of sheet metal. Moreover the manufacture of such elements or fasteners having hollow bodies is relatively costly and a problem exists that the contact surface is frequently not adequate. Furthermore. the radial dimensions of the part engaging surface of the fastener make it necessary to use a relatively large washer at the bolt side in order to transmit the forces in the desired manner.

The undercut in the sidewall of the fastener recess which is necessary to generate the required press-out resistance of the hollow body, is normally generated in such a way that the hollow element is subjected to a squeezing process at the outer peripheral jacket with the sidewall of the recess being brought from an initially axial parallel position into an inclined position. This results in the opening to the recess between the pilot part and the now inclined sidewall to be smaller in comparison to the base surface of the recess. Additionally, as a result of this squeezing movement, the hollow element also has an inclined surface at the outer jacket surface adjacent to the end face engaging the component. On attachment to the plate-like component, the wedge-shaped contact surface, facing the plate-like component, is frequently so deformed that it acts in a knife-like manner under load and a high surface pressure results between the component and the hollow element.

As a result of this high surface pressure the plate-like component yields after a few operating hours and no longer sits as tightly as designed, so that the danger of settlement and of reduction of the preload to zero exists, and thus the danger of failure of the threaded connection.

SUMMARY OF THE INVENTION

The present invention is based on the object of providing a fastener which can be manufactured economically and ensures good security against twist-out, a reliable seat after attachment to the plate-like component, and retains a firm seat even with changing loads without being torn out of the plate-like component and without loosening the bolt element that is used. Another advantage is that the contact surface can be smaller in diameter in comparison to prior solutions but nevertheless of adequate size area-wise so that an undesired high surface pressure does not arise at the plate-like component.

In order to satisfy this object, provision is made in accordance with the invention for the base surface of the fastener recess to extend up to the passage of the bore at least substantially preferably without a pilot portion.

The pilot portion which played a central role with the previously mentioned nut elements during the deformation of the plate-like component into the recess may be omitted in the disclosed embodiment of this invention. In this way, the radial dimensions of the nut element can be reduced approximately by the wall thickness dimensions of the customary pilot portion, whereby the inner diameter of the contact surface is made substantially smaller in diameter. This however also offers the possibility of dimensioning the outer diameter of the contact surface in comparison to the inner diameter in such a way that the radial width of the contact surface is larger. In this way an enlarged ring surface is present in comparison to the known hollow elements and the surface pressure can be reduced in operation. As a result of the changed dimensions the necessity of using a washer at the bolt side can be avoided.

In order to use this element with a hollow body, a modification of the die button and of the setting head is necessary to satisfy the functions previously satisfied by the pilot portion. In the prior art, the pilot portion serves on the one hand as a hole punch in order to punch out a slug from the sheet metal part in cooperation with a die button. This punching function is now achieved by means of a hole punch which is coaxially guided in the setting head relative to the hollow element and which, during the closing movement of the setting head, moves through the bore of the hollow element and in cooperation with the die button, serves to punch out a slug.

A hole punch of this kind is known, for example from the German patent 34 46 978 or from DE-OS 38 35 566.3; however, the hole punch is used there with a differently shaped hollow element which, so to say, also has a pilot portion in the form of a so-called rivetting section. Accordingly the use of a hole punch with a nut element without a pilot portion is not believed to be obvious.

Another function of the pilot portion in the hollow element of the prior art lies in forming the metal of the sheet metal component into the undercut in order to generate the security against push-out and additionally also the security against twist-out. This function is also taken on by the die button of the present invention and solved differently than before.

To generate the security against twist-out for the hollow element of the present invention, a number of end face recesses are pressed into the contact surface. The die button for the insertion of the nut element has a plurality of noses which ensure that the material of the plate-like component is pressed onto at least one of the end face recesses and preferably into a plurality of the recesses and generates a resistance against rotation. By way of example, eight

recesses can be provided in the contact surfaces and six noses on the die button whereby, independently of the respective rotational position of the fastener, at least one of the noses lies opposite a recess.

Through the use of a recess in the contact surface, undercuts are formed at the sidewall of the recess in the hollow element simultaneously with the forming of the recesses by pressing and indeed in the form of local bead-like deformations or rib portions of the sidewall or outer wall of the fastener recess. During the attachment process the sheet metal is pressed into the so formed undercuts which additionally ensures the required resistance to push-out and on the other hand however also forms an additional resistance against rotation.

Since the undercuts arise during the formation of the recess in the contact surface of the hollow element, and do not have to be generated by a squeezing movement at the jacket surface of the hollow element, the hollow element lacks the pronounced chamfer which arises with hollow elements in accordance with the initially named EP-A-0 553 822. This is however of advantage because it is then possible to form the transition from the contact surface into the jacket surface of the hollow element with only a small radius, for example of less than 0.5 mm, whereby the available surface of the contact surface is increased in comparison to the prior art.

In a second preferred embodiment of the self-attaching female fastener element of this invention, the end or contact face includes a continuous sinuate recess which extends arcuately toward and away from the sidewall or outer wall of the fastener recess. The outer wall or the fastener recess is also sinuate in shape, conforming to the sinuate shape of the continuous recess and forming the bead-like deformations or rib portions. As described, the rib portions overly the bottom wall of the fastener recess restricting the opening of the fastener recess and providing resistance to turning of the fastener when attached to a sheet metal part. In this preferred embodiment, the spaced bead-like deformations or rib portions are each inclined outwardly from the fastener recess outer wall, overlying the bottom wall.

The method of making a self-attaching female fastener element of this invention includes forming a nut blank having a central axis, a projecting flange portion on at least opposed sides of the central axis having a generally planar end face or contact surface and a fastener recess having a bottom wall and an outer wall defined by the flange portion extending generally perpendicular to the fastener recess bottom wall. In a conventional cold forming operation, the fastener bore will be partially formed in the nut blank. One preferred embodiment of the method of this invention then includes deforming the flange portion end face with a die member having an end face including a plurality of spaced projections separated by die recesses. The method includes driving the projections of the die member end face into the flange portion end face forming an end face recess in the flange portion end face and generally simultaneously deforming the fastener recess outer wall inwardly toward the central axis forming a plurality of spaced projecting bead-like deformations or rib portions as described above. The die recesses limit the penetration of the die member projections. When the bottom surface of the die recesses contact the end face of the flange portion, the force required for further deformation significantly increases and the press ram setting can then be set to stop further deformation. This assures very accurate formation of the bead-like projections or rib portions and accurately defines the diameter of the opening to the fastener recess.

In one preferred embodiment, the die member end face is inclined toward a central axis and the die member end face includes a plurality of spaced radially extending die recesses preferably having an arcuate bottom wall. The method then includes driving the die member projections into the flange portions end face until the arcuate bottom wall surface of the die recesses contact the flange portion end face. In another preferred embodiment of this invention, the die member end face includes a sinuate projecting die portion which forms the sinuate recess in the contact surface or end face of the flange portion of the nut blank. The method then includes driving the sinuate-shaped projection of the die member into the flange portion end face, forming a sinuate recess or groove in the end face of the flange portion and simultaneously deforming the sidewall or outer wall of the fastener recess radially inwardly forming the bead-like projections or rib portions described above. In this embodiment, the end face of the bead-like projections are generally co-planar with the end face of the flange portion and inclined from a mid portion of the outer wall of the fastener recess.

The method of this invention may also be used to form a restricted opening in other types of self-attaching fasteners including fasteners having a central pilot portion, wherein the fastener recess may be an annular groove surrounding the pilot portion or parallel grooves of a pierce nut. This method eliminates the requirement of forming re-entrant grooves or grooves having a dove-tailed configuration in a rolling operation. Other advantages and meritorious features of the present invention will be more fully understood from the appended drawings, claims and the description of the preferred embodiments below.

DESCRIPTION OF THE DRAWINGS

The invention will be explained in more detail in the following with reference to embodiments having regard to the drawings in which are shown:

FIG. **1** is a plan view on the end face of an element having a hollow body in accordance with the invention, with only one half of the hollow element being shown,

FIG. **2** is a partly sectioned side view of the hollow element of the invention in accordance with FIG. **1**,

FIG. **3** is a schematic illustration of the first phase of a method of the invention for attachment of the hollow element of FIGS. **1** and **2** to a plate-like component,

FIG. **4** is a later phase of the method of the invention shortly before the perforation of the plate-like component,

FIG. **5** is a later phase of the method of the invention immediately after the perforation of the plate-like component,

FIG. **6** is a still later phase of the method of the invention during the deformation of the plate-like component,

FIGS. **7**, and **7**A are the end of the method of the invention after the attachment of the hollow element to the plate-like component, with FIG. **7**A showing the arrangement of the die button in the lower tool,

FIG. **8** is a partly sectioned side view of the assembly consisting of the hollow element of the invention and a sheet metal part,

FIG. **9** is a somewhat modified embodiment of the hollow element of FIG. **1** in an illustration corresponding to that of FIG. **2**,

FIG. **10** is a further modification of the hollow element of FIG. 1, likewise in a representation in accordance with FIG. **2**,

FIG. **11** is a plan view of the contact surface of the hollow element of FIG. **10**,

FIG. 12 is a further illustration of a further embodiment of the hollow element of FIG. 1, again in an illustration in accordance with FIG. 2,

FIG. 13 is a top view of a die member which may be used in the method of this invention to form the self-attaching, female fastener element shown in FIGS. 10 and 11,

FIG. 14 is a side view of the die member shown in FIG. 13,

FIG. 15 is an end perspective view of the die member shown in FIGS. 13 and 14,

FIG. 16 is an end perspective view of a die member which may be used in the method of this invention to form the self-attaching fastener element shown in FIGS. 1 and 2,

FIG. 17 is an end cross-sectional view of FIG. 18, in the direction of view arrows 17—17,

FIG. 18 is a side cross-sectional view of the die assembly used in the method of this invention to form the self-attaching fastener element shown in FIGS. 1 and 2, and

FIGS. 19A–C illustrate various stages in the formation of the self-attaching fastener element shown in FIGS. 1 and 2 illustrating one preferred embodiment of the method of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THIS INVENTION

As seen in FIGS. 1 and 2, the disclosed embodiment of the self-attaching hollow element or fastener 10 consists of an essentially cylindrical body of metal having a projecting annular flange portion with an end face 12 which, after attachment of the element to a plate-like component, faces the plate-like component. The end face 12 has a fastener recess 14 which is arranged within a raised or projecting contact surface 16, with the base surface or bottom wall 18 of the fastener recess extending up to the bore 20 of the hollow element 10. The bore 20 has a central axis 22 which at the same time represents the longitudinal axis of the hollow element and is formed as a threaded bore with a thread 24, so that the hollow element shown is a nut element.

The base surface 18 of the fastener recess 14 merges via a shoulder 26 into a surface 28, with the outer diameter of the surface 28 being fractionally larger than the outer diameter D of the thread 24 provided in the bore 20. One notes that the bore 20 or the thread 24, the surface 28, the shoulder 26 and the recess 14 as well as the contact surface 12 lie coaxial to the central axis 22 of the hollow element 10. The further end face 31 of the hollow element is in this embodiment is made flat and simply provided with a small countersink 32 which forms a clean transition to the thread 24.

The stepped jacket surface 34 of the flange portion of the hollow element merges via a small radius 36 into the end face 12 and this radius 36 is preferably made smaller than 0.5 mm, for example 0.3 mm.

In the disclosed embodiment, the contact surface 16 has eight end face recesses 38 which, as can be seen from FIG. 2, are made substantially wedge-shaped and have their greatest depth at the transition into the sidewall or outer wall 15 of the fastener recess 14. In plan view the recesses 38 are approximately rectangular as can be seen from FIG. 1. These recesses are generated by cold forming during the manufacture of the nut element as described below and the corresponding deformation of the hollow element blank leads to bead-like projections or projecting portions 40 in the outer wall of the fastener recess 14, with these projections leading, as can clearly be seen from the left side of FIG. 2, to local undercuts 41 in the sidewall of the fastener recess 14.

As materials for the self-attaching or riveting elements, all materials can be used which in the context of cold forming achieve the strength values of class 8 in accordance with the ISO-standard, for example a 35 B2-alloy in accordance with DIN 1654. The so formed hollow elements or nut elements are suitable, amongst other things, for all commercially available steel materials for drawn quality sheet metal parts and also for aluminum or magnesium or their alloys. The nuts can also be formed in other materials, for example in aluminum alloy, in particular in an aluminum alloy of higher strength.

It will be understood that in FIG. 2, the formation of the nut element at the right hand side of the central axis 22 is identical to that on the left hand side.

The manner of attachment of the self-attaching element of FIGS. 1 and 2 in a plate-like component in the form of a sheet metal part 42 will be subsequently explained in more detail with reference to FIGS. 3 to 8.

In FIG. 3 the hollow element 10 of the invention is shown in an only partly illustrated setting head 44 which has a plunger 46 and also a hole punch 48 arranged coixially to the plunger 46. A setting head of this kind is known per se in principle from the above-mentioned German specifications, i.e. DE-PS 34 46 978 and DE-OS 38 35 556.3.

Beneath the sheet metal part 42 there is located a die button 50 which, as is for example illustrated in FIG. 7A, is inserted as a cylindrical component into a cylindrical bore 51 of a lower tool 52 of a press and is held at the correct height, flush with the surface of the lower tool 52 by means of a spacer 54. The die button 50 has a central bore 56 which merges via a ring shoulder 58 into a larger bore 60. The end face 62 of the die button 50 has a planar surface 64 which lies flush with the upper surface 66 of the lower tool 52. Furthermore the end face of the die button 50 has a hole-forming punch projection 68. The bore 56 which forms the aperture of the punch projection 68 has a cutting, edge 70 with an inner diameter which corresponds to that of the bore of the hollow element. The end face 72 arranged coaxial to the longitudinal axis 22 and which stands at least substantially perpendicular to this axis has a rounded drawing edge 74 at the transition to the jacket surface of the hole-forming punch projection 68.

A plurality of noses 76 are arranged at intervals around the punch projection. In this example six such noses are provided which are uniformly arranged around the hole-forming punch projection 68. The noses 76 have an inclined surface 78 and are formed in raised manner both at the jacket surface of the hole-forming punch projection 68 and also at the planar end face 64 of the die button 50.

The noses 76, which are as a whole rounded at all surfaces are made somewhat narrower than the recesses 38 in the contact surface 16 of the nut element 10. Through the use of the same reference numeral 22 it is made clear that the hole punch 48, the plunger 46, the lower end face 77 of the setting head, the hollow element 10 and the die button 50 of the lower tool 52 and also the bore 56 and the bore 60 of the die button and ultimately also the through-bore of the spacer 54 are all coaxially arranged.

The setting head 44 itself is arranged in known manner at the upper tool of a press and is so designed, in the usual manner, that the respective nut elements 10 pass through an inclined channel into the bore 80 of the setting head 44 and are subsequently guided by means of the plunger 46 during closing of the press to the end face of the setting head.

On closing of the press, for example for the shaping of the sheet metal part by the lower tool 52 in combination with an

upper non-illustrated tool, the setting head moves from the position of FIG. 3 to the position of FIG. 4. The lower end face 77 of the setting head 44 comes into contact with the sheet metal part 42 in this way and the sheet metal part is in turn pressed against the end face 72 of the die button 50. A further downward movement of the housing 79 of the setting head is prevented at this stage, the housing 79 of the setting head deflects rearwardly somewhat relative to the downwardly moving tool of the press. This also applies to the plunger 46 which advantageously presses against the shoulder 35 of the hollow element and not against the end face 31, whereby the danger of damaging the thread 34 is effectively avoided. The upper tool of the press however drives the hole punch 48 further downwardly initially into the position of FIG. 5. During this movement, the hole punch 48 cuts a slug 82 out of the sheet metal part 42 in cooperation with the cutting edge 70 of the hole-forming punch projection 68 of the die button 50, as shown in the sequential drawing of FIG. 5. In this manner a punched hole 83 is formed in the sheet metal part 42. One can see from this drawing that the hole punch 48 is slidingly received in the bore 56 of the die button 50 as well as in the bore 20 of the hollow element 10.

The slug 82 can be removed through the bore 60 of the die button 50 and the larger diameter of this bore 60 in comparison to the bore 56 ensures that the slug moves easily under gravity and does not become caught or stuck.

During the further closing movement of the press, the housing 79 of the setting head 44 and the plunger 46 are jointly moved further downwardly, as shown in FIG. 6, whereby the hole-forming punch projection 68 or, stated more precisely, the rounded drawing edge 74 of the hole-forming punch projection forms a collar 75 from the sheet metal material around the punched hole 83 while widening out the punched hole. This deformation continues up to the end stage as shown in FIG. 7 and one can see from FIG. 7 that the hole-forming punch projection 68 has so deformed the sheet metal material, or the collar 75, that this has been pressed in form-locked manner into the fastener recess 14 of the hollow element and into the undercuts 40.

As a result of the different number of noses 76 in comparison to the number of end face recesses 38 in the contact surface or end face 16 of the hollow element, it is ensured that at least one nose comes fully into alignment with an end face recess 38, and indeed without having to take any measures to secure the rotational position of the hollow element about the central axis 22. At least partial alignment with the noses of the die button can be expected for at least some of the other end face recesses 38, so that a form-locked contact also arises there, whereby the security against rotation is ensured.

Since the bead-like projections 40 which form the undercuts likewise lead to a corrugated surface of the sidewall of the fastener recess 14 the form-fitted contact of the sheet metal part against this sidewall likewise provides a significant contribution to the rotational security of the connection.

In the step illustrated in FIG. 7, the press opens again and the workpiece 42 together with the attached hollow element is ejected from the press or removed from the press and then presents itself as shown in FIG. 8. One can see from FIG. 8, that the inner diameter of the collar 75 of the sheet metal part 42 is somewhat larger than the outer diameter of the thread 24, so that the sheet metal part cannot prevent the insertion of a bolt. The bolt which its into the thread 24 is normally introduced in the direction of the arrow 86 and customarily serves to secure a second sheet metal part to the sheet metal part 42. It can be seen clearly from FIG. 8 that a considerable contact surface is present so that the surface pressure can be readily kept within permissible limits dependent on the material, and indeed also with a hollow element of a comparatively small diameter. The recesses 88 which are generated by the noses 76 in the sheet metal part are also evident in FIG. 8.

Although the hollow elements shown here all have a circularly cylindrical jacket surface, i.e. a circular cross-section in plane view, other cross-sectional shapes, for example polygonal shapes or oval shapes or cross-sectional shapes having grooves can also be used. The expression "ring-like" will also be understood to mean not only circular rings but rather also ring shapes which differ somewhat from a circular ring shape, such as for example a polygon. The sidewall 41 of the recess 14 can also take the form of a polygon or multi-sided figure. Further, although the self-attaching fastener element and method of installation of this invention has particular advantages as a pilotless annular fastening element, it will be understood that these advantages may also be incorporated in a self-attaching element having a central pilot including pierce nuts having parallel re-entrant grooves. Various variants of the invention can be conceived of which some will be explained in more detail with reference to the further FIGS. 9 to 12.

In the embodiment of FIG. 9, a projection 100 is located in the base region of the fastener recess 14. This projection 100 is not to be regarded as a pilot portion since it merely enables the use of a shortened thread or of a reduction in the height of the hollow element but otherwise has no function. It would however be conceivable to provide this projection 100 with noses and/or recesses, with the deformation of the sheet metal part against the noses and/or recesses making it possible to achieve an additional security against rotation. A design of this kind with noses 102 and recesses 104 can be seen in FIG. 12 and here the undercut is not only present through the formation of local recesses such as 38 in FIG. 1 but rather in the form of a sidewall or outer wall of the fastener recess 14 which has been inclined all around its periphery whereby a conical fastener recess 106 of the contact surface is generated. Since in the embodiment of FIG. 12 the recesses 38 which form a security against rotation are missing and the sidewall is an inclined wall, the noses 102, 104 represent the only security against rotation.

In the embodiment of FIG. 10, the contact surface 16 is provided with a continuous end face recess 108 which for example has a semicircular cross-section and is depressed at several circumferential locations in order to also form bead-like projections or rib portions 40 here, as in the embodiment of FIG. 1. When using such a profiled contact surface the die button should have a corresponding profile so that the sheet metal lies flush with the whole contact surface. The continuous end face recess 108 can also be so formed in the manner shown in FIG. 11, i.e. as a sinuate corrugated recess in plan view curving toward and away from the fastener recess 14 and wherein the rib portions 40 follow the sinuate contour of the recess or groove 108. When the die button has a form complementary to this as disclosed below, the required security against rotation is ensured by this recess 108. This recess 108 can also be so executed that the inner sidewall of the fastener recess 14 which receives projections 40 which also form undercuts which serve to generate the required push-out resistance and also offer an additional security against rotation.

An advantage of the hollow element of the invention lies in the fact that one hollow element can be used with sheet metal components of various thicknesses, for example metal sheets in the range from 0.75 mm to 2.25 mm. It is only

necessary to use a matching die button with the hole-forming punch projection having to have a larger diameter for thinner metal sheets than for thicker metal sheets.

FIGS. 13 to 15 illustrate one embodiment of a die member **110** suitable for forming the end face recesses **38** and rib portions or bead-like projections **40** of the fastener shown in FIGS. **10** and **12** described above. The die member includes a body portion **112**, and annular end face **114** and a central bore **116**. The annular end face **114** is sinuate as best shown in FIGS. **13** and **15**, including radially inwardly projecting arcuate portions **118** and radially outwardly projecting arcuate portions **120**. As best shown in FIG. **14**, the annular end face **114** is also sinuate in the side view, including projecting portions **122** separated by recesses **124**. The method of forming a self-attaching female fastener element using the die member shown in FIGS. **13** to **15** is described below. It will be understood by those skilled in the art, however, that the projecting portions **122** of the annular end face **114** may be discontinuous, rather than the preferred continuous sinuate form shown in FIGS. **13** to **15**.

The die member **128** shown in FIGS. **16** to **18** is specifically adapted to form the end face **12** of the self-attaching female fastener element **10** shown in FIGS. **1** and **2** as described below. The die member **128** includes a body portion **130** having an annular end face **132** surrounding a central bore **134**. In this embodiment, the end face **132** is in the form of a truncated cone which tapers upwardly to the central bore **134**. A plurality of spaced radially extending channel-shaped recesses **136** are formed in the annular end face **132** defining projecting radial portions **138** therebetween. In the disclosed embodiment, the recesses include an arcuate bottom wall **140** as shown in FIGS. **16** and **18**. The radially extending recesses **136** are spaced from the cylindrical outside surface **142** of the body portion **130** and the axial bore **134**.

FIG. **19** illustrates the final forming steps of the self-attaching female fastener **10** shown in FIGS. **1** and **2**. First, a nut blank is formed generally as shown in FIG. **19A**. The nut blank **10A** includes a fastener recess **14A** surrounding the partial bore **20A** formed in the nut blank in prior forming steps, not shown; however, the outer sidewall **15A** is generally cylindrical and the panel-supporting end face is planar. The external configuration of the nut blank may be identical to the female fastening element shown in FIGS. **1** and **2** and has been numbered accordingly.

The nut blank **10B** is then formed by the die member shown in FIGS. **16** and **17** as now described in regard to FIGS. **18** and **19B**. The nut blank **10A** is received in a cylindrical nose member **144** beneath a reciprocating plunger which drives the nut against the annular end face **132** of the die member. Alternatively, the die member **128** may be driven against the end surface **12A** of the nut blank, as shown in FIG. **18**. As the conical annular end face **132** of the die member **128** is driven against the end face **12A** of the nut blank **10A** as shown in FIG. **18**, the projecting portions **138** between the radial die recesses **136** deforms the metal of the nut blank adjacent the opening to the fastener recess forming a wedge shaped end face recesses **38**, as shown in FIG. **2**, and substantially simultaneously deforms the bead-like projections **40** overlying the bottom wall **18** of the fastener recess **14** as described above in reference to FIGS. **1** and **2**. The amount of deformation of the end face **12** of the nut blank is controlled by the bottom wall **140** of the radially recesses in the die member **128**. When the bottom walls **140** of the die member recesses engage the end face **12A** of the nut blank, the force required for further deformation significantly increases. Thus, the force of the die is easily set to stop further deformation. This results in very accurate forming of the bead-like projections or ribs **40** and the end face recesses **38**, such that the inside diameter between the bead like projections **40** is very accurately controlled. This accurate formation of the undercuts **41** (see FIG. **2**) is important in the attachment of the self-attaching female fastening element described above. The bore **20** in the nut blank **10C** is then completed by driving a punch through the partially formed bore opening **20B** as shown in FIG. **19C**. The bore may remain unthreaded where a thread-forming stud or male fastener is used or the bore may be threaded by a conventional tapping operation as shown in FIGS. **1** and **2**.

Although the pilotless self-attaching female fastening element **10** of this invention has several advantages over the prior art as described above, the method of forming a fastener element of this invention may also be used to form an undercut having spaced bead-like projections or ribs **40** in many types of fasteners. For example, this method may be used to form a re-entrant groove or a groove having a restricted opening in a fastener of the type disclosed in U.S. Pat. No. 4,971,499 or piloted fasteners of the type discussed above. A fastener of the type shown in FIGS. **10** and **11** may be formed with the die member shown in FIGS. **13** to **15** by the same method disclosed above in regard to FIG. **18**. That is, the nut blank **10A** is located opposite a die member as shown in FIG. **18**, except that the die member will be generally as shown in FIGS. **13** to **15**. The projecting portions **122** of the die end face **114** is then driven into the end face **12A** forming a continuous recess sinuate **108** in the contact surface **16** of the nut blank **10A**, which simultaneously forms the spaced bead-like projections or ribs overlying the bottom wall of the fastener recess as shown in FIGS. **10** and **11**. As will be understood by those skilled in the art, various configurations of fastener elements may be formed by this method and this method may be used to form a restricted opening to the recess in any type of self-attaching fastener.

What is claimed is:

1. A method of making a self-attaching female fastening element for attachment to a sheet metal part, said method comprising the following steps:

forming a nut blank having a central axis, a projecting flange portion on at least opposed sides of said central axis having a generally planar end face, and a fastener recess having a bottom wall and an outer wall defined by said flange portion extending generally perpendicular to said fastener recess bottom wall; and

deforming said flange portion end face with a die member having an end face including a plurality of spaced projections separated by die recesses, said method including driving said projections of said die member end face into said flange portion end face forming an end face recess in said flange portion end face, and generally simultaneously deforming said fastener recess outer wall inwardly toward said central axis forming a plurality or spaced projecting rib portions projecting from said fastener recess outer wall generally adjacent said flange portion end face overlying said fastener recess bottom wall and defining spaced inclined undercuts at the opening to said fastener recess.

2. The method of making a self-attaching female fastening element as defined in claim **1**, wherein said spaced die recesses in said die member end face include a bottom surface, said method including continuing to drive said die member projections into said flange portion end face until said die recesses contact said flange portion end face,

thereby limiting deformation of said fastener recess outer wall and accurately forming said projecting rib portions.

3. The method of making a self-attaching female fastening element as defined in claim **1**, wherein said die member end face is inclined toward a central axis of said die member, and said spaced die recesses including a generally arcuate bottom wall, said method including continuing to drive said die member projections into said flange portion end face until said arcuate bottom wall surface of said die recesses contact said flange portion end face, thereby limiting deformation of said fastener recess outer wall and accurately forming said projecting rib portions.

4. The method of making a self-attaching female fastening element as defined in claim **1**, wherein said method includes forming a bore through said nut blank coincident with said central axis following deformation of said flange portion end face with said die member.

5. The method of making a self-attaching female fastening element as defined in claim **1**, wherein said die member end face comprises an annular surface surrounding a central bore, said annular surface including a plurality of radial die recesses spaced from said central bore defining said projections therebetween, said method including driving said die member end face annular surface into said planar flange portion end face, said die member end face projections deforming said flange portion end face forming a plurality of spaced end face recesses in said flange portion end face and deforming said fastener recess outer wall radially inwardly toward said central axis forming said projecting rib portions.

* * * * *

United States Patent [19]

Boxall

BEST AVAILABLE COPY

[11] **4,039,099**

[45] **Aug. 2, 1977**

[54] **SECURING OF RIVETS TO PORTABLE ARTICLES**

[75] Inventor: Charles W. Boxall, Norwich, England

[73] Assignee: National Can Corporation, Chicago, Ill.

[21] Appl. No.: 657,191

[22] Filed: Feb. 11, 1976

[51] Int. Cl.² B65D 25/32

[52] U.S. Cl. .... 220/91; 16/114 R; 29/243.52; 29/512; 85/37; 190/58 A; 220/94 R

[58] Field of Search .... 220/94 R, 94 A, 91, 220/92, 95, 272; 16/125; 29/512, 523, 243.52, 243.53; 190/58, 57; 113/120 J; 403/282, 285; 85/37; 151/41.72; 224/45 P

[56] **References Cited**

U.S. PATENT DOCUMENTS

748,581	1/1904	Carll	16/125
1,833,795	11/1931	Renshaw	113/120 J
2,029,328	2/1936	Ljungström	220/270
2,067,945	1/1937	Peters	29/523
2,096,823	10/1937	Penny	29/512
2,359,193	9/1944	Bechik	16/125
3,084,826	4/1963	Ericson	29/523
3,195,767	7/1965	Henchert	220/272

FOREIGN PATENT DOCUMENTS

559,369	10/1957	Belgium	220/91
1,323,261	7/1973	United Kingdom	220/94 R

Primary Examiner—William Price
Assistant Examiner—Allan N. Shoap
Attorney, Agent, or Firm—Dressler, Goldsmith, Clement, Gordon & Shore, Ltd.

[57] **ABSTRACT**

A deformable metal rivet is permanently attached to a sheet metal wall by deforming a tubular extension on the free end of the rivet shank around an inwardly directed rim surrounding an opening in the sheet metal wall. The resultant article includes a rivet that has an extension turned around the inwardly directed rim surrounding a hole which receives the rivet to clinch the rivet on the sheet metal wall.

1 Claim, 9 Drawing Figures

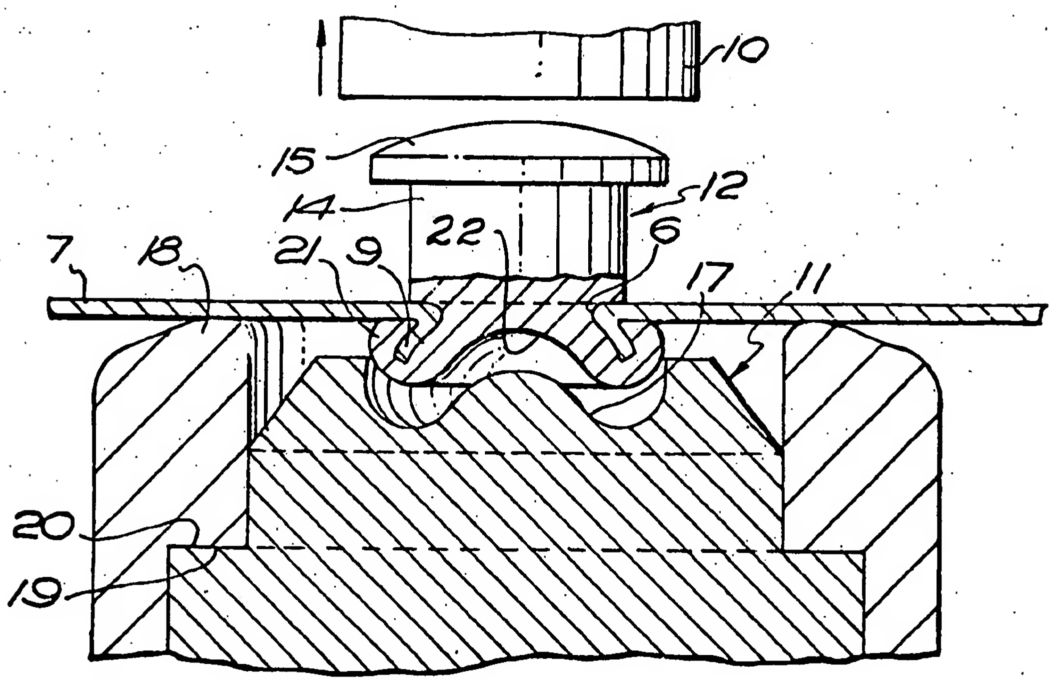


FIG. 1

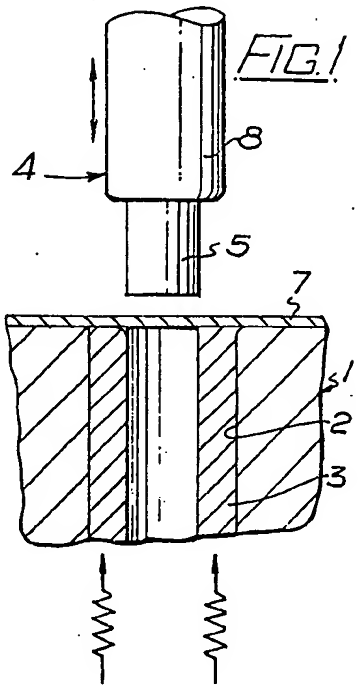


FIG. 2

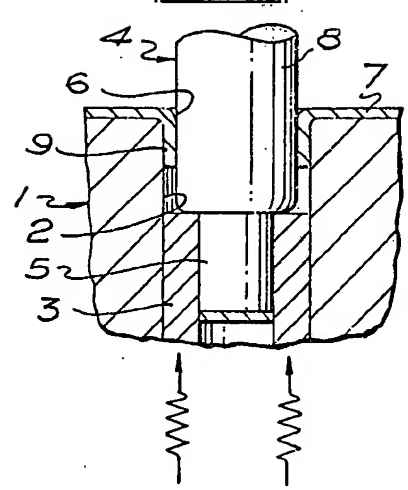


FIG. 3

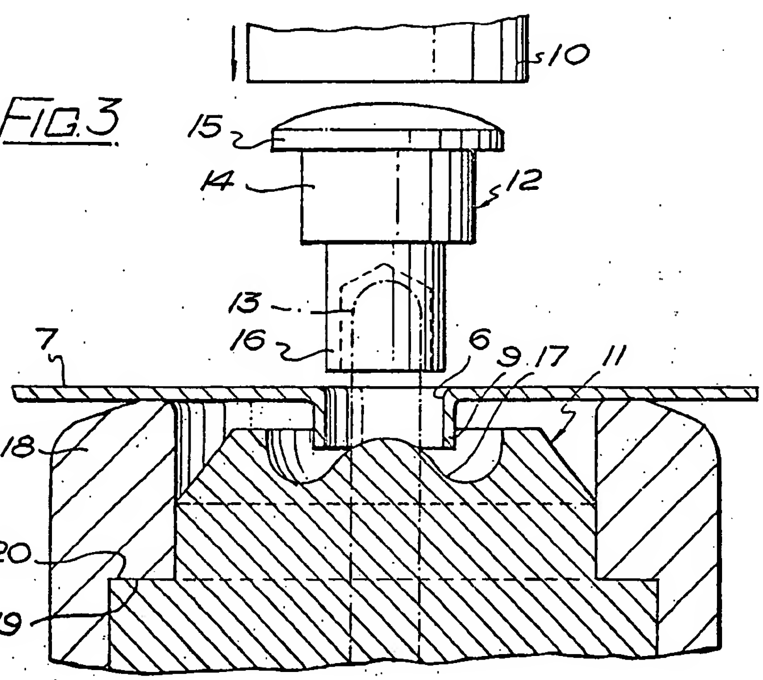


FIG. 4

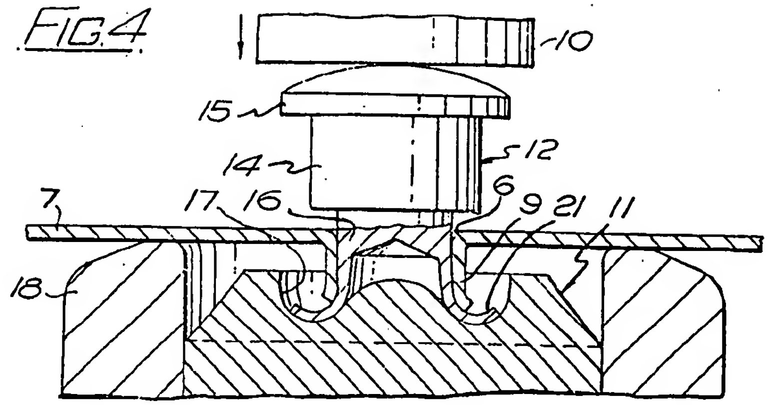


FIG. 5

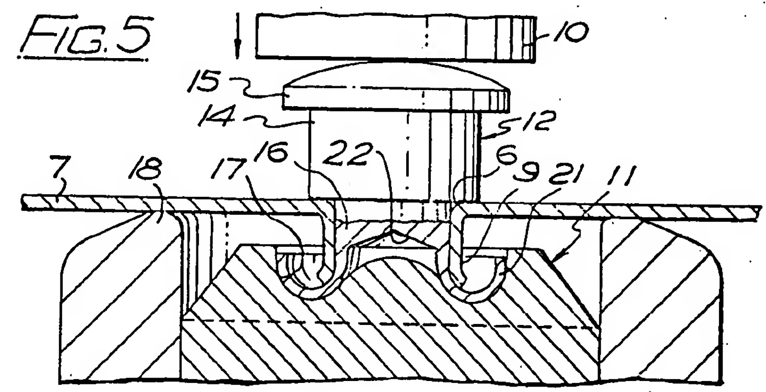


FIG. 6

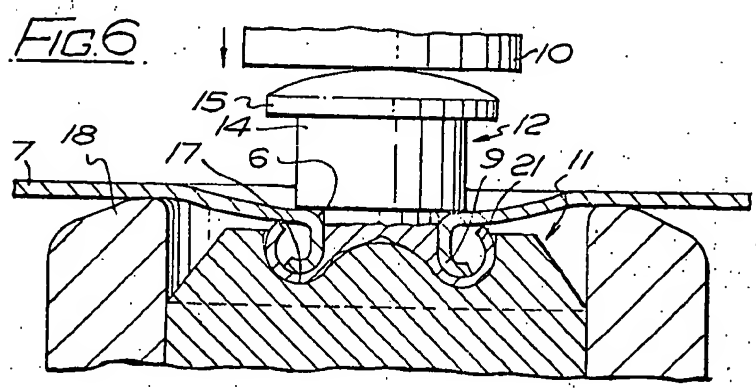


FIG. 7

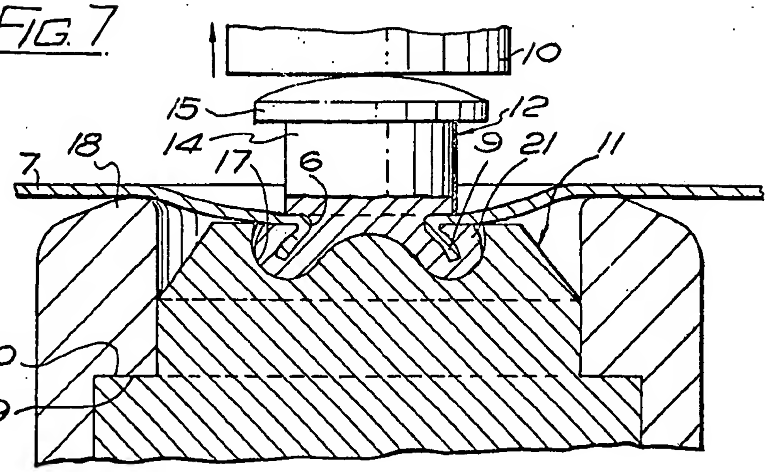
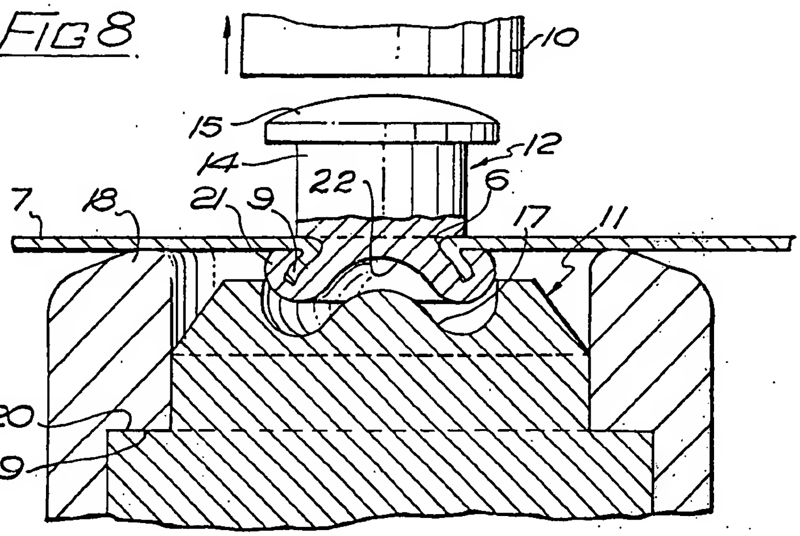


FIG 8



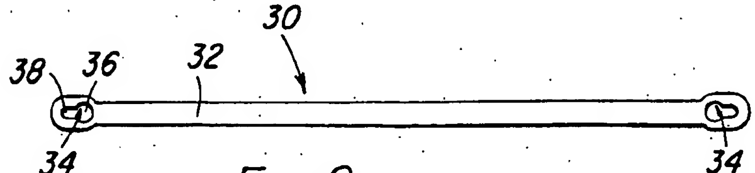


FIG. 9.

SECURING OF RIVETS TO PORTABLE ARTICLES

BACKGROUND OF THE INVENTION

This invention relates to the securing of rivets to portable articles for the reception of carrying handles for the articles, and more particularly to such articles having wall portions formed from sheet metal, such as cans for holding paint or other substances.

Whereas U.K. Pat. Application No. 19652/72 describes how the rim of a hole for a rivet can be folded or turned back on to the associated wall portion to provide a certain amount of resilience to effect the required seal between the rivet and the wall portion, the object of the present invention is also to provide a stronger mechanical grip between the rivet and the wall portion than has hitherto been usual.

SUMMARY OF THE INVENTION

According to one aspect of the invention, therefore, a method of securing a deformable metal rivet to a sheet metal wall portion of a portable article comprises forming a hole in the wall portion with an inwardly directed rim, inserting a rivet into the hole, and deforming the rivet in a manner such that it is first turned round the inwardly directed rim of the hole and then clenched thereon.

The two-stage deformation of the rivet results in the inwardly directed rim of the hole being prevented from being folded or turned back on to the associated wall portion. However, as the rivet is turned round the rim the latter is deformed towards the associated wall portion so as to become keyed in the deformed material of the rivet and be gripped tightly when the rivet is clenched thereon, whereby the rivet is very firmly sealingly secured to the wall portion. Indeed, the rivet is so firmly secured that it cannot be parted from the wall portion by pulling the rivet without effecting irreparable damage to the wall portion.

According to another aspect of the invention, a portable article has a pair of metal rivets each secured to a respective wall portion of the article with shanks of the rivets, each of which has a head, protruding outwardly from the wall portions, wherein the wall portions are of sheet metal and each has a hole with a rim directed inwardly, and the associated rivet has an extension fitting through the hole, turned round the inwardly directed rim of the hole and clenched thereon.

A carrying handle having a pair of apertures thereon of a size intermediate the shanks and the heads of the rivets may be secured to the article by passing each rivet through a respective one of the apertures in the handle before the extension is fitted through the hole and deformed. Alternatively, the rivets may be arranged to receive a detachable carrying handle, for example as disclosed in U.K. Pat. Specification No. 1,323,261.

The extension of the rivet is preferably initially tubular so as to facilitate turning it round the inwardly directed rim of the hole, but the formation of tooling for effecting deformation of the rivet (whether provided with a tubular extension or not) is important in ensuring the two-stages of deformation.

All these aspects of the invention will now be described with reference to the accompanying drawings which show in enlarged fragmentary sections various stages in the application of a rivet to a sheet metal wall portion.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

FIG. 1 shows a die and piercing punch for forming a hole and inwardly directed rim in a wall portion of an article;

FIG. 2 is a view similar to FIG. 1 showing the parts after the hole and rim have been formed;

FIG. 3 shows a punch, anvil and rivet arranged for attachment to the wall portion;

FIGS. 4 through 7 show the various stages of rivet and rim deformations and the position of the punch and anvil at each stage;

FIG. 8 shows the final condition of the rivet and wall after the rivet is clenched on the wall; and

FIG. 9 is a plan view of a carrying handle adapted to be attached to the rivets.

DETAILED DESCRIPTION

While this invention is susceptible of embodiment in many different forms, there is shown in the drawings and will herein be described in detail a preferred embodiment of the invention with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the embodiment illustrated.

In FIGS. 1 and 2 a die 1 has a recess 2 in which a sleeve 3 is spring-loaded upwardly, and a piercing punch 5 has a leading portion 5 for piercing a hole 6 in a sheet metal wall portion 7. Piercing punch 4 has an enlarged body portion 8 which has a diameter less than the recess 2 in the die 1 but greater than the opening in shade 3 for deforming the rim 9 of the pierced hole into the recess 2. The spring-loaded sleeve 3 serves to eject the rim 9 of the pierced hole from the recess 2 when the punch 4 is withdrawn.

in FIGS. 3 to 7 a rivetting punch 10 is reciprocable towards and away from an anvil 11 to effect driving of a deformable metal rivet 12 through the hole 6 in the sheet metal wall portion 7 and rivetting therein. The rivet may be fed by any of the usual magazine feeds (not shown); and the anvil may be provided with an axially retractable central pin 13 (shown in broken line in FIG. 3 only) for assisting manual location of the hole in the wall portion and possibly also a hole in one end of a metal handle (not shown) to be rivetted at the same time, but an anvil in an automated production line will not require such a pin as precise location can be effected as part of accurately controlled intermittent movement of the metal sheet.

The rivet 12 has a shank 14, with enlarged head 15 at one end, and reduced extension 16 at the other end of the shank for fitting through the hole 6. The extension 16 of the rivet is tubular, so as to assist the operative surface 17 of the anvil 11 is producing the desired deformation of the rivet.

The anvil 11 has a coaxial annular element 18 extending beyond the operative surface 17 to an extent such that the edge of the rim 9 of the hole 6 in the sheet metal wall portion 7 directed towards the anvil cannot make contact with the operative surface. For convenience of manufacture and maintenance the annular element 18 is formed as a separate sleeve counterbored to form an annular abutment 19 seating on an annular shoulder 20 on the anvil.

The extension 16 of the rivet 12 driven by the rivetting punch 10 is deformed by the operative surface 17 of

the anvil **11**, the deformed material **21** (FIGS. **4** to **6**) of the rivet being turned — in usual manner — but because the edge of the rim **9** of the hole **6** in the sheet metal wall portion **7** canot make contact with the anvil, the deformed material of the tubular end portion **16** of the rivet is turned round the rim of the hole until the deformed material reaches the associated wall portion (FIG. **6**), when the rim of the hole will be deformed towards the associated wall portion and then become keyed in the deformed material of the rivet as the latter is clenched thereon (see FIG. **7**). This results from the fact that the convex surface **17** is moved towards and ultimately engages a surface **22** defined on the inner end of shank **14** within the confines of hollow tubular end portion **16**.

Between the stage at which the shank **14** of the rivet **12** makes contact with the wall portion **7** around the hole (FIG. **5**) and the stage at which the rivet is clenched (FIG. **7**), the wall portion **7** flexes (see FIG. **6** and **7**), but its resilience enables it to spring back after retraction of the rivetting punch **10** (FIG. **8**).

It will be appreciated from FIGS. **7** and **8** that the rim **9** of the hole **6** in the wall portion **7** becomes keyed in the deformed material **21** of the rivet **12** and is gripped tightly, whereby the rivet is very firmly sealingly secured to the wall portion and cannot be parted therefrom by pulling the rivet without effecting irreparable damage to the wall portion.

FIG. **8** shows the tubular end portion **16** in its deformed condition and also shows the unique relation of rim **9** and deformed portion **21**. In its final condition sheet metal rim **9** extends away from opening **6** and defines an acute included angle of substantially less than 90° with wall portion **7**, when viewed in cross-section as illustrated in FIG. **8**. The deformed metal **21** is clenched around the outwardly bent rim so as to be in contiguous engagement with the entire exposed surfaces of rim **9** and also engages the inner surface of wall portion **10**.

In its final condition of the deformed metal of tubular rivet, the inner surface **22** is concave and concave surface **22** is arcuate in cross section down to the lowermost or inner end of deformed portion **21**.

FIG. **9** shows an illustrative type of detachable carrying handle **30** which is fully described in U.K. Pat. Specification No. 1,323,261. Carrying handle **30** consists of an elongated strap **32** preferably formed from a flexible plastic material having elongated apertures **34** adjacent opposite ends. Each aperture has an enlarged circular portion **36** at one end and a reduced elongated portion **38** at the opposite end. Circular portion **36** has a diameter slightly greater than the diameter of head **15** while elongated portion **38** has a transverse dimension that is less than the diameter of head **15** and slightly greater than the diameter of shank **14**. Thus, carrying handle **30** can be attached to rivets **12** by passing heads **15** through the enlarged circular portions **36** and carrying handle **30** moved relative to rivets **12** so that shanks **14** are received into elongated portions **38** while heads **15** overlay portions of the trap adjacent portions of strap **32**.

What we claim is:

1. A portable article having a pair of metal rivets each of which is permenently secured to a respective flat wall portion of the article, each of said rivets including a solid shank portion engaging an outer surface of said flat wall portion and an enlarged head on an outer end of said shank spaced from said flat wall portion to receive a carrying handle, said shank having a reduced tubular end portion extending from an end opposite said enlarged head with said flat wall portion having an opening receiving said tubular end portion said flat wall portion having an inwardly directed rim integral therewith and surrounding said opening with said rim defining an acute included angle in cross section with said flat wall portion so that said rim extends away from said opening, said solid shank portion having a concave surface in cross section at said opposite end adapted to engage a tool for deforming said tubular end portion, said tubular end portion being permanently deformed completely around said rim and being contiguous to both opposed surfaces thereof, said tubular end portion engaging an inner surface of said flat wall portion to permanently secure said rivet to said flat wall portion.

* * * * *

US 20030123947A1

(19) United States

(12) **Patent Application Publication** (10) **Pub. No.: US 2003/0123947 A1**

Eshraghi (43) **Pub. Date: Jul. 3, 2003**

(54) **BLIND RIVET WITH HOLLOW HEAD**

(76) Inventor: **Soheil Eshraghi**, Irvine, CA (US)

Correspondence Address:
Trexler, Bushnell, Giangiorgi,
Blackstone & Marr, Ltd.
36th Floor
105 West Adams Street
Chicago, IL 60603 (US)

(21) Appl. No.: **10/034,434**

(22) Filed: **Dec. 27, 2001**

Publication Classification

(51) **Int. Cl.**[7] **F16B 13/04**

(52) **U.S. Cl.** **411/43**

(57) **ABSTRACT**

The present invention provides a fastener for securing workpieces together which has a stem having an enlarged head at one end thereof that has a cavity therethrough, a main sleeve and an expander sleeve. The expander sleeve is adapted to move into a bore of the main sleeve to radially expand the main sleeve to form a first blind head for clamping the workpieces together in response to a first axial force. The enlarged stem head is adapted to move, without any deformation thereto, into a bore of the expander sleeve to radially expand the expander sleeve to form a second blind head to further clamp the workpieces together in response to a second axial force. The fastener further has a breakneck groove on the stem adapted to fracture the stem in response to a third axial force.

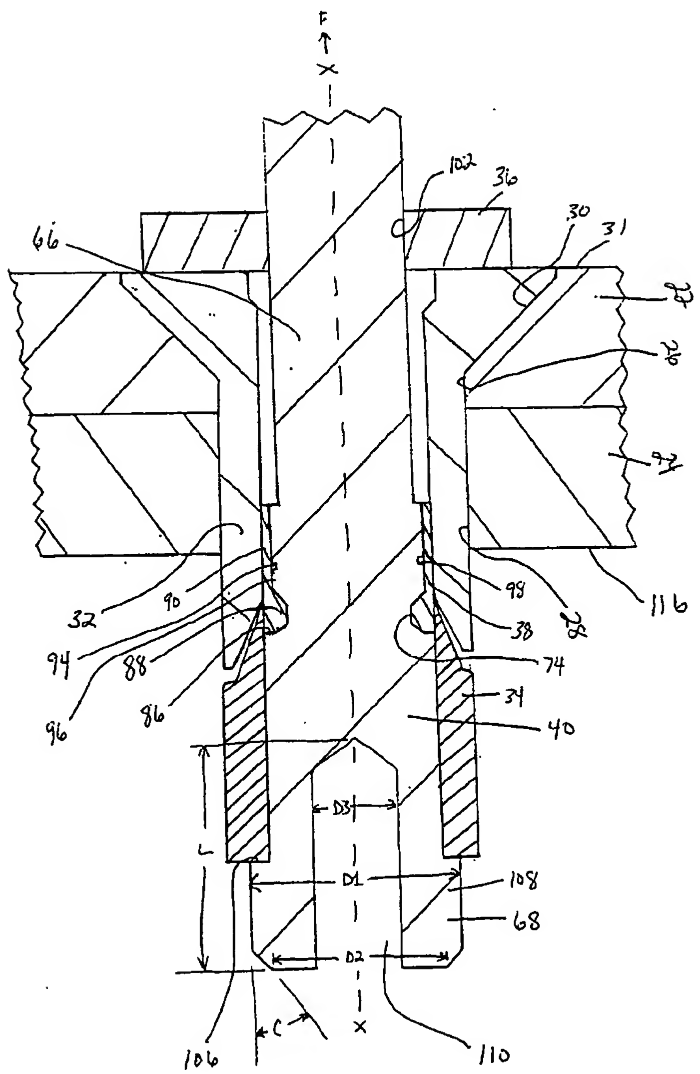


FIG. 1a

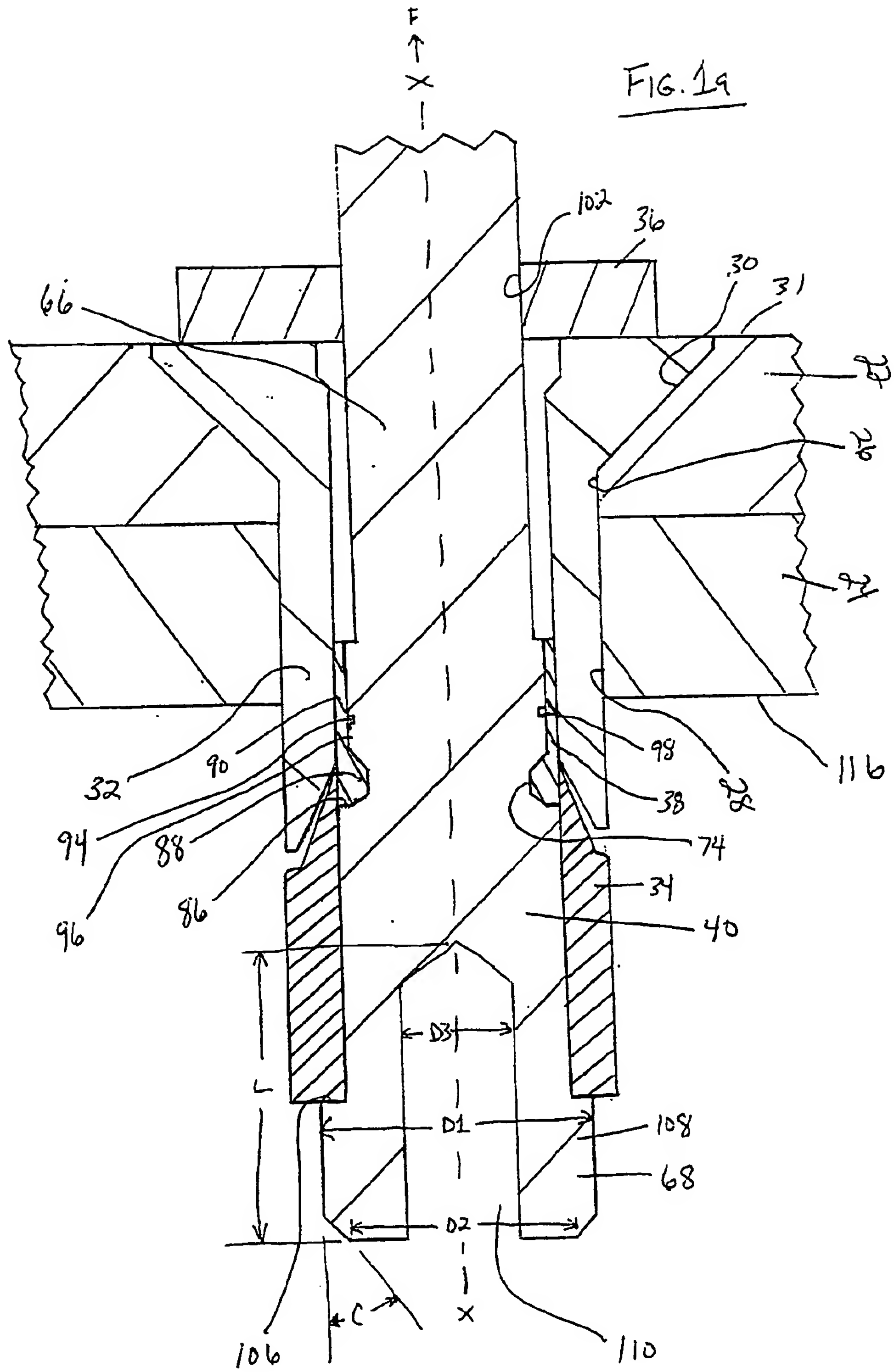

F
X
102
36
30
31
66
90
32
98
38
94
88
74
34
96
86
40
L
D3
D1
108
68
D2
C
X
106
110
116

FIG. 1b

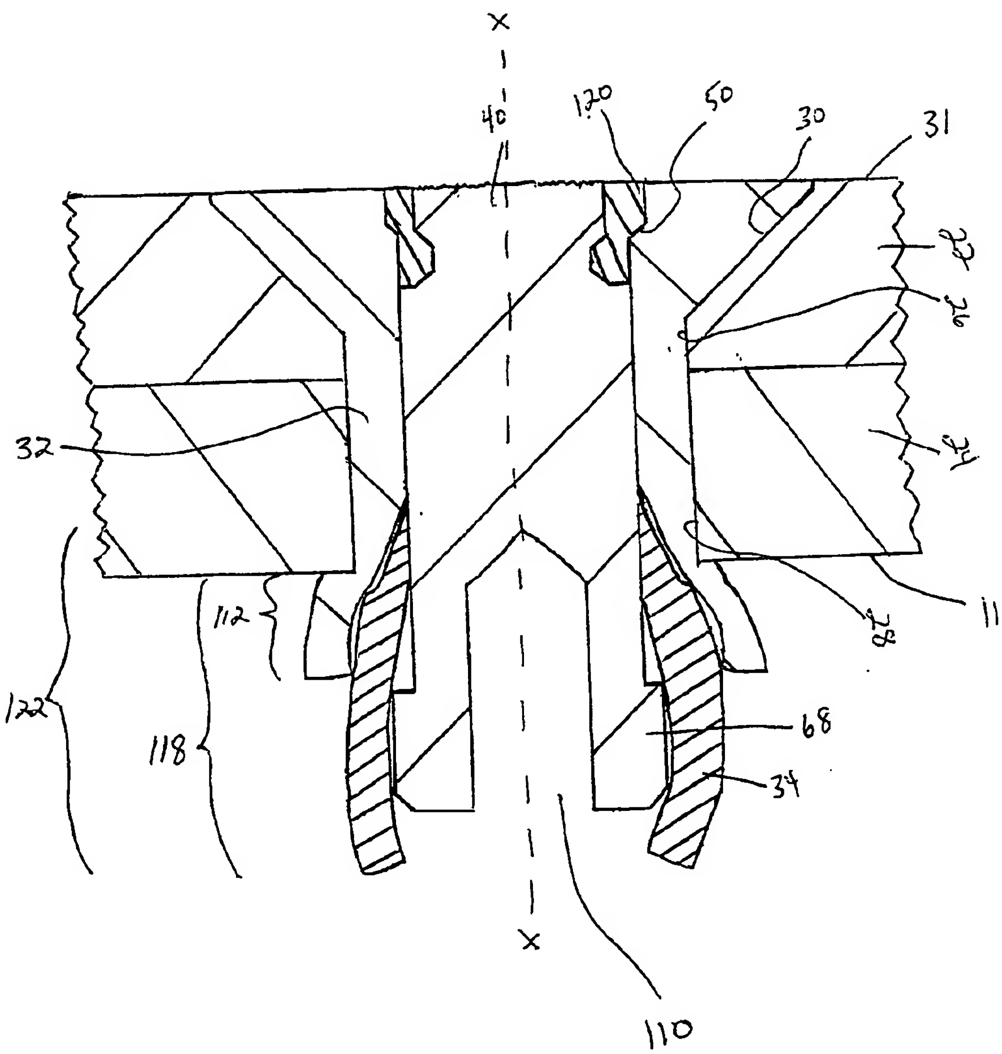


Fig. 2

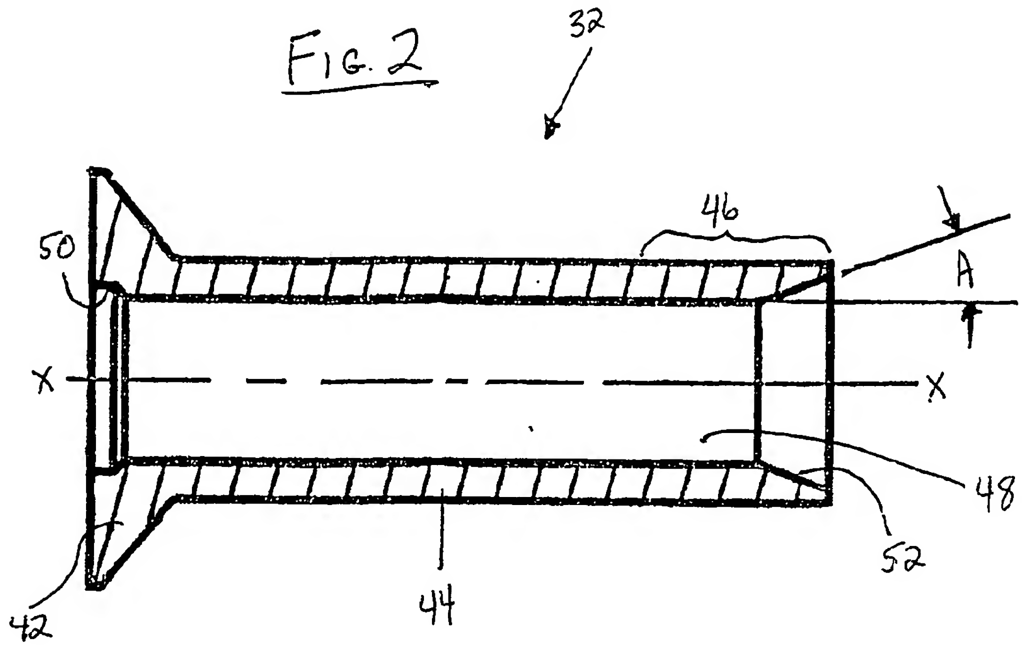
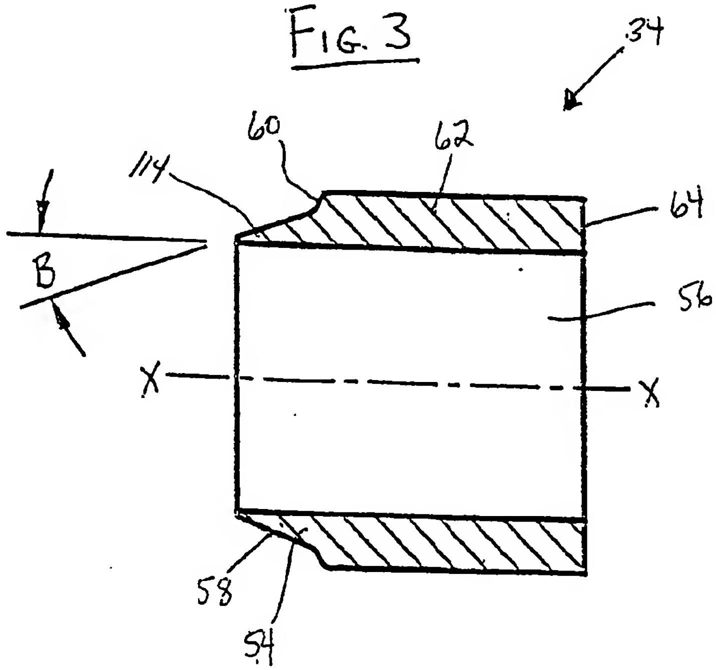


Fig. 3



BLIND RIVET WITH HOLLOW HEAD

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a novel blind fastener.

[0002] Blind fasteners are fasteners which are applied from one side of a pair of workpieces, such as an aircraft frame, construction members, or the like. Examples of blind fasteners are shown, for example, in U.S. Pat. Nos. 3,369,289; 4,863,325 and 6,077,009. Numerous types and configurations of blind fasteners exist.

[0003] Typically, the blind fastener is inserted from an access side of such workpieces, and, by means of a manual or power operated setting tool, is caused to be secured firmly in place. Blind fasteners have been very useful in the manufacture of various different articles and machines, such that today millions of such devices are manufactured and used.

[0004] As millions of these fasteners are made by companies around the world, it would be beneficial to have a fastener which uses less material than the other fasteners currently on the market, but which maintains all of the structural and mechanical properties of the other fasteners currently on the market. In addition, with regard to aircraft frames, weight is also a significant consideration.

[0005] The present invention provides such a fastener, as will herein be explained, which maintains all of the structural and mechanical properties desired, but which also reduces the amount of material and, thus, the weight of the fastener. Other features and advantages of the present invention will become apparent upon a reading of the specification in combination with a study of the drawings.

OBJECTS AND SUMMARY OF THE INVENTION

[0006] A primary object of the invention is to provide a fastener having a cavity formed in a stem thereof which minimizes the weight of the stem, as well as the amount of material used, while maintaining the desired mechanical and structural properties of the fastener.

[0007] Another object of the invention is to provide a fastener having a cavity formed in a stem thereof which does not cause the stem to substantially, if at all, deform during a fastening process.

[0008] Yet another object of the invention is to provide a fastener having a cavity formed in a stem thereof such as to reduce the cost of making the fastener.

[0009] Briefly, and in accordance with the foregoing, the present invention provides a novel blind fastener for securing workpieces having aligned bores therethrough together. The blind fastener has a stem having an enlarged head at one end thereof that has a cavity therethrough, a main sleeve and an expander sleeve. The expander sleeve is adapted to move into a bore of the main sleeve to radially expand the main sleeve to form a first blind head for clamping the workpieces together in response to a first axial force supplied to the fastener by an installation tool. The enlarged stem head is adapted to move, without any deformation thereto, into a bore of the expander sleeve to radially expand the expander sleeve to form a second blind head to further clamp the workpieces together in response to a second axial force supplied to the fastener by the installation tool. The fastener further has a breakneck groove on the stem adapted to fracture the stem in response to a third axial force supplied to the fastener by the installation tool.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The features of the present invention which are believed to be novel are described in detail hereinbelow. The organization and manner of the structure and operation of the invention, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawings wherein like reference numerals identify like elements in which:

[0011] **FIG. 1***a* is a side elevational, cross-sectional view of the blind fastener of the present invention including a stem member shown partly broken away, a main sleeve, an expander sleeve, lock ring and drive washer as initially assembled to workpieces to be fastened together;

[0012] **FIG. 1***b* is a side elevational, cross-sectional view depicting the fastener of **FIG. 1***a* at the completion stage of the installation of the workpieces from the start condition of **FIG. 1***a*;

[0013] **FIG. 2** is a side elevational, cross-sectional view of the main sleeve of the fastener; and

[0014] **FIG. 3** is a side elevational, cross-sectional view of the expander sleeve of the fastener.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

[0015] While this invention may be susceptible to embodiment in different forms, there is shown in the drawings and will be described herein in detail, a specific embodiment with the understanding that the present disclosure is to be considered an exemplification of the principles of the invention, and is not intended to limit the invention to that as illustrated.

[0016] The fastener **20** as shown in **FIG. 1***a* is adapted to secure together outer and inner workpieces **22, 24**. The workpieces **22, 24** have bores **26, 28** therethrough, respectively, which are aligned with one another. The bore **26** preferably terminates at its outer end in a large diameter tapered or countersunk counterbore **30** in the outer surface **31** of the outer workpiece **22**. The fastener **20** as illustrated includes a main sleeve **32**, an expander sleeve **34**, a drive washer **36**, and a lock ring **38** supported upon a stem member **40**. It is to be understood, however, that the invention is not limited to this illustrated embodiment, and may be employed with alternate designs.

[0017] The main sleeve **32**, best illustrated in **FIG. 2**, is of a tubular form and has an enlarged head **42** on the outer end of a cylindrical sleeve shank **44**. The enlarged head **42** is of the flush or conical type and is adapted to fit in the tapered counterbore **30** of the outer workpiece **22**, see **FIG. 1***a*. It is to be understood that the main sleeve **32** could be of the type with an enlarged protruding head. The cylindrical sleeve shank **44** terminates at its inner or blind side end in a radially expandable, blind head section **46**. The cylindrical shank **44** of the main sleeve **32** is of a uniform outside diameter

adapted to be received through bores **26**, **28** of workpieces **22**, **24**, respectively. The main sleeve **32** has an internal bore **48** extending therethrough. The enlarged head **42** has an annular counterbore or recess **50** at the outer end of the bore **48** for a purpose to be described. The bore **48** at the blind head section **46** of the main sleeve **32** terminates at its inner end in a radially outwardly tapered bore segment **52** which serves a purpose to be described. The bore segment tapers at an angle A relative to a central axis X of the main sleeve **32** and hence of the fastener **20**. The main sleeve **32** is preferably formed of one of the following materials: aluminum, such as aluminum 5056 alloy, precipitation-hardening stainless steel, such as A-286, alloys containing nickel and copper, better known as MONEL®—manufactured by Inco Alloys International, Inc., and alloys containing nickel, chromium and iron, better known as INCONEL®—manufactured by Inco Alloys International, Inc.

[0018] The expander sleeve **34**, best illustrated in **FIG. 3**, is of a cylindrical form and has a tapered expansion section **54** which, as will be seen, is adapted to engage the blind head section **46** of the main sleeve **32** to form a blind head. The expander sleeve **34** has a generally uniform through bore **56** which is of a diameter generally the same as the diameter of the main sleeve bore **48**. The expansion section **54** has a tapered outer surface **58** which tapers radially outwardly at an angle B relative to the central axis X of the fastener **20**. The tapered outer surface **58** tapers from an outer diameter which is slightly greater than the diameter of bore **48** of main sleeve **32** to a preselected larger end diameter. The expansion section **54** further has an arcuate outer surface **60** which curves radially outwardly and then radially inwardly relative to axis X of the fastener **20**. The arcuate outer surface **60** curves from the tapered outer surface **58** to a straight shank portion **62**. The opposite or outer end surface **64** of the expander sleeve shank portion **62** is generally, transversely flat. The expander sleeve **34** is preferably formed of one of the following materials: precipitation-hardening stainless steel, such as A-286, 300 series stainless steel alloys, such as 304 stainless steel alloy, and 400 series stainless steel alloys, such as 400 stainless steel alloy.

[0019] As can be seen in **FIG. 1***a*, the stem member **40** includes an elongated shank **66** and a stem head **68**. The elongated shank **66** extends through the main sleeve **32** and the expander sleeve **34**. The elongated shank **66** has a pulling portion (not shown) at its outer end, which is provided with a plurality of annular pull grooves (not shown) so that it can be gripped by a conventional pull type tool. Such tools are well known in the art and, therefore, the details thereof have been omitted for purposes of brevity and simplicity. The enlarged stem head **68** is provided at the blind end of the stem shank **66** and operates in a manner to be described whereby the blind head section **46** of the main sleeve **32** is expanded into an enlarged, high strength blind head as shown in **FIG. 1***b* for clinching the workpieces **22**, **24** together under a high clamp load. The stem member **40** is preferably formed of one of the following materials: precipitation-hardening stainless steel, such as A-286 or 15-7, and alloys containing nickel, chromium and iron, better known as INCONEL®—manufactured by Inco Alloys International, Inc.

[0020] An annular lock groove **74** is formed on the stem shank **66** at a distance from the stem head **68**. The annular lock groove **74** is formed on the stem shank **66** within the grip range of the fastener **20** so that, upon completion of the installation after the workpieces **22**, **24** have been clinched together and a blind head structure formed, the lock groove **74** is still within the enlarged sleeve head **42** of main sleeve **32**. The grip range of a fastener, such as fastener **20**, is the range of total thicknesses of the workpieces **22**, **24** from a minimum total thickness to a maximum total thickness which it can secure together.

[0021] The lock ring **38** has a locking boss **88** of increased thickness which fits into the annular lock groove **74**. A reduced thickness lock sleeve portion **90** of the lock ring **38** extends forwardly or outwardly along the stem shank **66**. The lock ring **38** is of a uniform cylindrical configuration and generally conforms to the area between the shank **66** and the main sleeve **32**, and is of a circumferentially open construction defined by a narrow axial slit (not shown). The open construction permits the lock ring **38** to be resiliently, radially expanded to facilitate its assembly into the lock groove **74**. An enlarged, straight stem shank shoulder **86** is adapted to bear against the radially outer end of the locking boss **88** of the lock ring **38** to thereby move the lock ring **38** with the stem member **40** and, as will be seen, to apply the load to the lock ring **38** to form the front lock.

[0022] A weakened breakneck groove **94** is located on the stem shank **66** spaced outwardly from the lock groove **74**. An annular land **96** is located between the lock groove **74** and the breakneck groove **94** and is of a larger diameter than the breakneck groove **94** so as to form a stem stop shoulder **98**.

[0023] The stem shank **66** has a splined portion (not shown) located distal to, and between, the pulling portion and the breakneck groove **94**. The splined portion is of a larger diameter than the pulling portion such as to provide an interference fit with a through bore **102** of the drive washer **36**. The drive washer **36** is adapted to engage the enlarged sleeve head **42** and to react against the lock ring **38**. The interference fit of the drive washer bore **102** with the splined portion holds the drive washer **36**, the main sleeve **32**, and the expander sleeve **34** assembled to the stem member **40** in order to facilitate handling of the fastener **20**. In this regard, the splined portion is connected to the outer end of the breakneck groove **94** by a shank portion (not shown) which is of a reduced diameter so as to be able to pass through the drive washer bore **102** in clearance. In this regard, the pulling portion can also pass through the drive washer bore **102** substantially in clearance.

[0024] The enlarged stem head **68** has an enlarged diameter, axially straight head portion **108**. The head portion **108**, which is of a uniform diameter D1, tapers angularly, radially inwardly at its outer end, having a diameter D2, at an angle C relative to axis X of the fastener **20**. The diameter D1 is preferably slightly larger than the diameter D2.

[0025] A cavity **110** is provided in the enlarged stem head **68** and extends into the stem shank **66**. The cavity **110** has a uniform diameter D3 at the end of the enlarged stem head **68** and extends through the enlarged stem head **68** and into the stem shank **66** at a preselected length L. The cavity **110** tapers to a point within the stem shank **66**. The diameter D3 is preferably approximately ⅗ of the diameter D2, while the length L is preferably larger than the length of the enlarged stem head **68**. The cavity **110** minimizes the weight of the stem member **40** while maintaining the desired

mechanical and structural properties of the fastener **20**, such that the cavity **110** does not cause the stem member **40** to substantially, if at all, deform during a fastening process.

[0026] As pre-assembled, the tapered expansion section **54** of the expander sleeve **34** is adapted to nest matingly within the tapered segment **52** of the bore **48** of the main sleeve **32**. At the same time, the rearward or blind end flat surface **64** of the sleeve shank portion **62** is in planar engagement with the enlarged stem head **68**.

[0027] To install the fastener **20**, a relative axial force "F" is applied between the stem member **40** and the expander sleeve **34** and main sleeve **32** by a pull tool which grips the pull grooves of pulling portion with the tool having an anvil member engaging the drive washer **36**, as is standard in the art. The drive washer **36** at the same time transmits the load to the main sleeve **32** by its engagement with the enlarged sleeve head **42**. As this occurs, the enlarged stem head **68**, by engagement with the outer end surface **64**, applies an axial force on the expander sleeve **34** which in turn applies an axial force on the main sleeve **32** via the tapered expansion section **54**. As the load increases, the tapered expansion section **54** is moved axially into the blind head section **46** as guided by the tapered bore segment **52**. This causes the blind head section **46** to be expanded radially outwardly to form a first blind head **112**, see **FIG. 1***b*. This continues until the leading end **114** of the tapered expansion section **54** is substantially at the rear or blind side surface **116** of inner workpiece **24** in order to provide the first blind head **112** with substantial strength. In this condition, the clamp load on the workpieces **22**, **24** is essentially secured by the first blind head **112** at the blind side surface **116** and by the enlarged sleeve head **42** at the counterbore **30**. However, the lock ring **38** is still not in position to create the lock between the stem member **40** and the main sleeve **32** at the outer or open end.

[0028] As the relative axial force is increased, the stem head **68** is moved axially inwardly past the outer end surface **64** of the shank portion **62** to form a second blind head **118**, see **FIG. 1***b*. It should be noted that a stem head shoulder **106** of the enlarged stem head **68** extends radially for a distance which is less than the wall thickness or radial length of the flat end surface **64**. The limited radial length of the stem head shoulder **106** relative to the wall thickness at the end surface **64** is selected to provide sufficient resistance to movement of the stem head **68** into the expander sleeve **34** until after the first blind head **112** is substantially fully formed. This facilitates the maximization of the axial movement of the leading end **114** of the expansion section **54** into the blind head section **46** to a position proximate to the blind side surface **116** resulting in maximizing the strength of the first blind head **112** and the magnitude of final clamp load. At the same time, the wall thickness of the straight shank portion **62** is also selected to resist buckling.

[0029] The stem head **68** will be moved axially inwardly into the expander sleeve **34** until the lock sleeve portion **90** of the lock ring **38** is in engagement with the drive washer **36**. As the relative axial pulling force exerted on the stem shank **66** and on the sleeve head **42** increases, the lock sleeve portion **90** is deformed radially outwardly to form an interlocking annular flange **120** in the recess **50**, to firmly interlock the stem shank **66** with the main sleeve **32**. At the same time, the stem stop shoulder **98** has engaged the drive washer **36**. When this occurs, further relative axial force on the stem shank **66** will be resisted, causing the stem shank **66** to break at the weakened breakneck groove **94** at about the outer surface of the enlarged head **42**. The locking sleeve portion **90** of the lock ring **38** initially overlaps the breakneck groove **94** sufficiently to provide for the formation of the interlocking flange **120**, by the time the stem stop shoulder **98** abuts the drive washer **36**.

[0030] At this point a multiple blind head assembly **122** is fully formed and includes the locking and strength interaction of the first blind head **112**, the second blind head **118**, the stem head **68** and the stem shank **66**. The severed portion of the stem shank **66** and the drive washer **36** will be discarded.

[0031] It should be noted that after final installation upon full formation of the lock flange **120** and the fracture of the breakneck groove **94**, the annular land **96** will be in line with the recess **50** in the enlarged head **42** to define a restricted cavity which cooperates with the lock groove **74** to secure the lock ring **38** and hence to positively lock the stem member **40** to the main sleeve **32** at the outer end.

[0032] During the fastening process discussed with reference to **FIGS. 1***a*-**1***b*, the enlarged stem head **68** and the stem shank **66** proximate to the stem head **68** do not substantially, if at all, deform or lose their shape because of the cavity **110** formed therein. The cavity **110** is of such a size and dimension, and the characteristic properties of the material used to form the stem member **40** are balanced so as to minimize the weight of the stem member **40** while maintaining the desired mechanical and structural properties of the stem member **40**. The cavity **110** merely acts to reduce the weight of the stem member **40**, but not at the expense of any desired mechanical or operational characteristics of the fastener **20**. In other words, the cavity **110** provides no mechanical function in the fastening process.

[0033] The blind head assembly **122** has high strength resulting from the interengagement of the expander sleeve **34** within the main sleeve **32** with the leading end **114** of the expansion section **54** located very proximate to the blind side surface **116** of the inner workpiece **24**. The presence of the cavity **110** does not minimize this strength in any way. The expander sleeve **34** also has high strength which assists in such high blind head assembly **122** strength as does the formation of the second blind head **118** and overengagement of the stem head **68** by the expander sleeve **34**. All of the above factors contribute to forming a blind head assembly **122** having a high strength and lock.

[0034] Thus, the fastener **20** herein accomplishes positive mechanical locking of the stem member **40** to the sleeves **32**, **34** without loss of clamp load and with the formation of the multiple locked blind head assembly **122** having a high strength structure which will resist deformation, even with the presence of the cavity **110**.

[0035] It should further be noted that the use of the cavity **110** in the described fastener **20** can be imparted to all types of fasteners that have a stem or a pin in order to reduce the weight of the fasteners without losing any of the desired mechanical or structural properties of the fasteners.

[0036] Again, it is to be understood that the invention is not limited to this illustrated embodiment, and may be employed with alternate designs. For example, the fastener

20 can be solely used with a sleeve 32 wherein the head 68 of the fastener 20 causes the sleeve 32 to expand to lock the blind fastener with the workpieces 22, 24.

[0037] While a preferred embodiment of the present invention is shown and described, it is envisioned that those skilled in the art may devise various modifications without departing from the spirit and scope of the foregoing description.

The invention is claimed as follows:

1. A blind fastener for securing workpieces having aligned bores therethrough, said blind fastener comprising:

a stem having an elongated stem shank with an enlarged stem head at a blind end of said elongated stem shank and gripping means at an end opposite of said blind end, said enlarged stem head having a cavity provided therein;

a sleeve engaged with the workpieces and having first and second ends, an expandable section located at said second end, said sleeve having a bore therethrough and being supported on said elongated stem shank;

said enlarged stem head being adapted to move, without any deformation thereto, relative to said sleeve to deform said expandable section to form a blind head, said enlarged stem head and said cavity being dimensioned such that said enlarged stem head does not collapse during deformation of said sleeve.

2. A blind fastener as defined in claim 1, wherein said cavity provided in said enlarged stem head extends through said enlarged stem head and into said elongated stem shank.

3. A blind fastener as defined in claim 2, wherein said cavity has a diameter which is approximately ⅗ of a diameter of said enlarged stem head.

4. A blind fastener as defined in claim 2, wherein said cavity extends into said elongated stem shank a length that is only a small portion of an overall length of said stem.

5. A blind fastener as defined in claim 1, wherein said cavity has a diameter which is approximately ⅗ of a diameter of said enlarged stem head.

6. A blind fastener as defined in claim 1, wherein said stem is formed of a material selected from the group consisting of precipitation-hardening stainless steel, and alloys containing nickel, chromium and iron.

7. A blind fastener as defined in claim 1, wherein said sleeve is formed of a material selected from the group consisting of aluminum, precipitation-hardening stainless steel, alloys containing nickel and copper, and alloys containing nickel, chromium and iron.

8. A method of securing workpieces having aligned bores therethrough with a blind fastener, said method comprising the steps of:

a) providing a blind fastener including a stem having an elongated stem shank with an enlarged stem head at a blind end of said elongated stem shank and gripping means at an end opposite of said blind end, said enlarged stem head having a cavity provided therein, a sleeve having first and second ends, an expandable section located at said second end, said sleeve having a bore therethrough and being supported on said elongated stem shank;

b) inserting said blind fastener through the bores of the workpieces such that said enlarged stem head of said stem is proximate a blind surface of the workpieces and said gripping means of said stem is proximate an accessible surface of the workpieces; and

c) providing an axial force to said gripping means by an installation tool to move said stem relative to said, thereby moving said enlarged stem head into said expandable section of said sleeve to form a blind head for clamping the workpieces together without causing any deformation to said enlarged stem head, said enlarged stem head and said cavity being dimensioned such that said enlarged stem head does not collapse during deformation of said sleeve.

9. A blind fastener for securing workpieces having aligned bores therethrough, said blind fastener comprising:

a stem having an elongated stem shank with an enlarged stem head at a blind end of said elongated stem shank, gripping means at an end opposite of said blind end, and a breakneck groove on said elongated stem shank positioned between said gripping means and said enlarged stem head, said enlarged stem head having a cavity provided therein;

a main sleeve having an enlarged sleeve head located at a first end of said main sleeve, a blind head section located at a second end of said main sleeve, and a sleeve shank portion located between said enlarged sleeve head and said blind head section, said main sleeve having a bore therethrough and being supported on said elongated stem shank;

an expander sleeve having a bore therethrough and being located on said elongated stem shank between said enlarged stem head and said blind head section of said main sleeve;

said enlarged sleeve head of said main sleeve being adapted to be in engagement with an accessible side of the workpieces and said sleeve shank portion of said main sleeve being adapted to extend through the bores of the workpieces;

said expander sleeve being adapted to move into said bore of said main sleeve at said blind head section of said main sleeve to radially expand said main sleeve to form a first blind head for clamping the workpieces together in response to a first relative axial force supplied to said fastener by an installation tool adapted to grip the gripping means on said stem;

said enlarged stem head being adapted to move, without any deformation thereto, into said bore of said expander sleeve to radially expand said expander sleeve to form a second blind head to further clamp the workpieces and to secure said stem, in response to a second relative axial force supplied to said fastener by the installation tool, said enlarged stem head and said cavity being dimensioned such that said enlarged stem head does not collapse during deformation of said sleeve; and

said breakneck groove being adapted to fracture said elongated stem shank in response to a third relative axial force supplied to said fastener by the installation tool.

10. A blind fastener as defined in claim 9, wherein said stem further includes an annular lock groove on said elon-

gated stem shank proximate to said breakneck groove and between said breakneck groove and said enlarged stem head, and an annular lock ring located in said annular lock groove and completely inside said sleeve shank portion of said main sleeve, and being axially spaced from said enlarged sleeve head of said main sleeve.

11. A blind fastener as defined in claim 10, further including a locking boss on said annular lock ring which allows said annular lock ring to move with said elongated stem shank through said bore of said main sleeve.

12. A blind fastener as defined in claim 9, wherein said cavity has a diameter which is approximately ⅗ of a diameter of said enlarged stem head.

13. A blind fastener as defined in claim 9, wherein said stem is formed of a material selected from the group consisting of precipitation-hardening stainless steel and alloys containing nickel, chromium and iron.

14. A blind fastener as defined in claim 9, wherein said main sleeve is formed of a material selected from the group consisting of aluminum, precipitation-hardening stainless steel, alloys containing nickel and copper, and alloys containing nickel, chromium and iron.

15. A blind fastener as defined in claim 9, wherein said expander sleeve is formed of a material selected from the group consisting of 300 series stainless steel alloys, 400 series stainless steel alloys, and precipitation-hardening stainless steel.

* * * * *

United States Patent [19]

Marling

[11] **4,204,308**

[45] **May 27, 1980**

[54] **SCREW EXTRACTING DEVICE**

[76] Inventor: **Douglas S. Marling**, 2511 Elizabeth St., Janesville, Wis. 53545

[21] Appl. No.: **929,899**

[22] Filed: **Aug. 1, 1978**

[51] Int. Cl.² **B23P 19/02; B25B 13/50**

[52] U.S. Cl. **29/426.5**; 81/53.2

[58] Field of Search .... 81/53.2, 91 R, 113, 81/114; 254/18; 279/42, 43, 48, 50, 56, 57; 145/1 R, 50 R; 29/427

[56] **References Cited**

U.S. PATENT DOCUMENTS

1,116,532	11/1914	Armstrong	279/42
1,141,741	6/1915	Wiseman	145/52
2,750,821	6/1956	Hilsinger	81/53.2
3,735,650	5/1973	Weng	81/53.2
4,078,766	3/1978	Saurwein	254/18

Primary Examiner—James L. Jones, Jr.

Attorney, Agent, or Firm—Larson, Taylor and Hinds

[57] **ABSTRACT**

A screw extracting device is provided for removing screws which cannot be removed with an ordinary screwdriver. The device comprises an elongate rod, a handle located at one end of the rod, a plurality of gripping fingers located at the other end of the rod for gripping the screw to be extracted a sleeve, threaded for movement along the rod, for controlling contraction and expansion of said gripping fingers in accordance with the longitudinal position of said sleeve along the rod so as to provide gripping and release of the screw head. The fingers each include a tapered tip portion which permits the fingers to be driven into the surface surrounding the head of the screw to be extracted and gripping ridges or the like for providing firm gripping of the screw head. A method of using the device is also enclosed.

7 Claims, 6 Drawing Figures

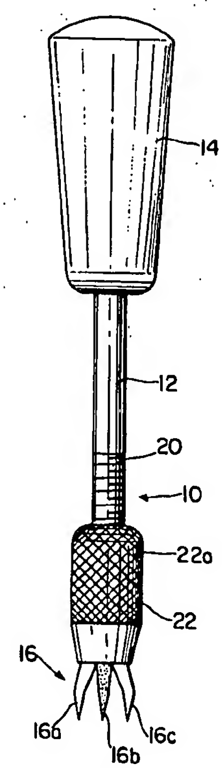


FIG. 1

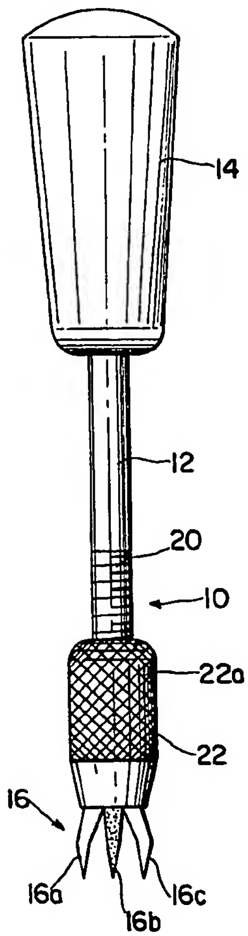


FIG. 2

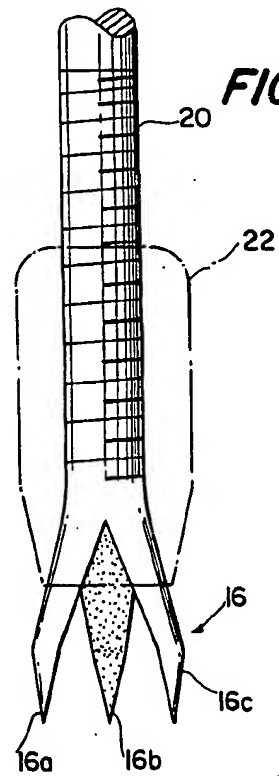


FIG. 3

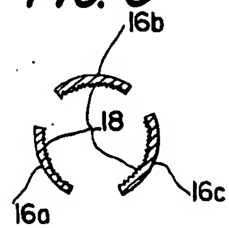


FIG. 4(a)

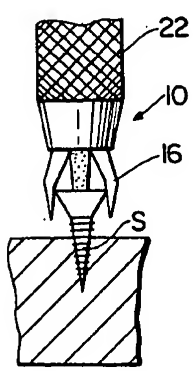


FIG. 4(b)

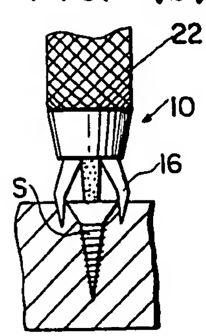
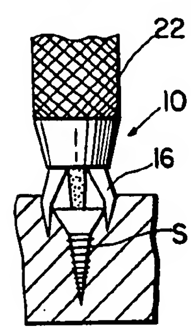


FIG. 4(c)



SCREW EXTRACTING DEVICE

FIELD OF THE INVENTION

The present invention relates to a device and method for extracting "stripped" or deformed screws notwithstanding the state of the screw.

BACKGROUND OF THE INVENTION

In many instances, screws whose heads have been "stripped" or otherwise deformed or damaged cannot be extracted using a conventional screwdriver. Screws get into this state because of the improper use of tools, wear and the like, and removal of such screws generally presents a frustrating problem. In this regard, a particularly vexing situation is presented when the screw head has been driven in so as to be flush with, or lie below, the surface which the screw is screwed into. A number of techniques are used to extract stripped screws, these techniques generally involving "brute forcing" the screw through the use of heavy pliers or the like, or where applicable, digging out the screw using whatever tool is available. None of these techniques is particularly successful in practice and thus a need exists for a simple, easy to use tool which enables a screw to be extracted when the head is stripped or otherwise damaged and which can be used even where the screw head lies flush with, or below, the surface into which the screw extends.

SUMMARY OF THE INVENTION

In accordance with the invention, a screw extracting device is provided which possesses the desirable characteristics discussed above and overcomes the problems associated with prior art techniques for removing screws which cannot be removed with an ordinary screwdriver. The device of the invention is easy to use and is relatively simple to manufacture. Further, the screw extracting device is rugged in construction and removes screws in a highly effective, efficient manner even where the screw head lies flush with or below the working surface.

According to a preferred embodiment of the invention, a screw extracting device is provided which comprises an elongate rod member which is threaded along a portion of the length thereof; a handle located at one end of the rod member; a plurality of gripping fingers located at the other end of the rod member for gripping the screw to be extracted; a control sleeve, threaded for movement along the rod member, for controlling contraction and expansion of the gripping fingers in accordance with the longitudinal position of the said sleeve along the rod member so as to permit a screw to be gripped and released. The fingers each include a tapered tip portion which permits the fingers to be driven into the surface surrounding the head of the screw to be extracted and means located thereon for providing firm gripping of the screw head. These gripping means preferably comprise gripping ridges on fingers similar to those found on pliers. Advantageously, the tips of said fingers are of a chisel-like configuration to enable the fingers to be driven into the working surface in which the screw is imbedded so that the fingers can be brought into engagement with the head.

In a specific embodiment, three gripping fingers are disposed in equispaced relationship around a common longitudinal axis. The fingers are formed integrally with the rod member and are biased outwardly away from their common longitudinal axis. The sleeve is tubular and the outer surface of said sleeve is knurled to enhance gripping.

The invention also involves a method of extracting a screw head which is substantially flush with or lies below the surface into which the screw extends which utilizes a screw extracting device as described above. The method comprises applying a force to one end of the screw extracting device so as to drive the gripping fingers into the surface to a depth such that the fingers, when closed, will firmly engage the head of the screw; screwing the control sleeve down on the rod, i.e., towards the gripping fingers, so as to cause the gripping members to close about the head of the screw; and rotating the device to cause unscrewing of the screw.

Other features and advantages of the invention will be set forth in, or apparent from, in detailed description of a preferred embodiment found hereinbelow.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view of a screw extracting device in accordance with a preferred embodiment of the invention;

FIG. 2 is a detail, drawn to an enlarged scale and with the control sleeve shown in phantom, of the screw extracting device of FIG. 1;

FIG. 3 is an end elevational, drawn to an enlarged scale, of the gripping fingers of the device of FIG. 1 illustrating the gripping surfaces; and

FIGS. 4(*a*), 4(*b*) and 4(*c*) illustrate the method of use of the screw extracting device of the invention for three different positions of the screw to be extracted.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, a preferred embodiment of the screw extracting device of the invention is illustrated. The device, which is generally denoted **10**, includes a rod member **12** having a handle **14** attached to one end thereof. In an exemplary embodiment, rod **12** is fabricated of steel or a like metal while handle **14** is fabricated of wood or plastic.

As perhaps can be best seen in FIG. 2, the other end of rod **12** is formed to provide three gripping fingers **16***a*, **16***b* and **16***c*, which are collectively denoted **16**. In a specific example, rod **12** is approximately 6 inches in length and ⅜ inch in diameter, and fingers **16** are formed by boring out the end of the rod **12** to a depth of approximately 1 and ¼ inches and a diameter of 3/16 inch. The fingers **16** then formed by splitting the bored out end of the rod **12**. The fingers so formed are forced open, or outwardly, slightly so as to define a circle having diameter larger than the ⅜ inch outside diameter of rod **12**. It will be appreciated that fingers **16** can take other forms and, for example, could be provided separately from rod **12** and pivotably connected to the end thereof. In this embodiment, a spring or the like would be utilized to bias the fingers outwardly. An example of a tool which utilizes such an arrangement is disclosed in U.S. Pat. No. 803,692 (Hill).

The ends of fingers **16** are tapered in the manner of the end of a chisel, as illustrated, and the tip of each is provided with a plurality of ridges, indicated at **18** in FIG. 3 and similar to those found on a pair of pliers, to provide more secure gripping of the head of a screw. As indicated in cross section in FIG. 3, ridges **18** extend parallel to one another longitudinally of the fingers **16**.

Rod member 12 is provided with screw threads 20 along the end thereof opposite handle 14 beginning at the base of fingers 16. A control sleeve 22 is threaded over this end of rod 12 for controlling opening and closing of gripping fingers 16. The inside diameter of sleeve 22 is nominally the same as the outside diameter of rod 12 and the threading of each is such that sleeve 22, when rotated, travels along the length of rod 12 in the manner of a traveling nut. The outer surface of sleeve 22 is knurled, as indicated at 22*a*, to provide improved gripping. Thus, by screwing sleeve 22 up and down along the length of rod 12, fingers 16 are progressively engaged and released so that they contract and expand.

The operation of screw extracting device 10 will be considered in connection with FIGS. 4(*a*), 4(*b*) and 4(*c*). If the head of a screw becomes "stripped" so that the slot in the head normally engaged by a screwdriver is damaged or destroyed or if one is unable to remove the screw for any reason (such as the lack of an appropriate tool), the fingers 16 of screw extracting device 10 are placed over the head of the screw. Sleeve member 22 is then screwed down on rod 12 towards fingers 16 so as to cause fingers 16 to tighten around the head of the screw and firmly grip the same. After this is done, the screw is simply unscrewed by rotating device 10 using handle 12. FIG. 4(*a*) illustrates a situation wherein the head of a screw S extends above the surface in which the screw is embedded. The head is readily gripped by fingers 16 under these circumstances. In FIGS. 4(*b*) and 4(*c*), the screw head is flush with surface and below or beneath the surface, respectively. In this situation, the screw extracting device 10 is placed over the head of screw S and handle 14 is tapped so as to drive the tapered fingers 16 into the surface to such an extent that the ends of fingers 16 are able to grip the screw head. The fingers 16 are then tightened by means of sleeve 22 to firmly grip the screw head and the screw is then unscrewed.

Although the invention has been described relative to exemplary embodiments thereof, it will be understood that other variations and modifications can be effected in these embodiments without departing from the scope and spirit of the invention.

I claim:

1. A screw extracting device which is particularly adapted for removing screws which cannot be removed with an ordinary screwdriver, said device comprising:
- an elongate rod member threaded along a portion of the length thereof;
- a handle located at one end of said rod member;
- a plurality of elongate, longitudinally extending gripping fingers located at the other end of said rod member for gripping the screw to be extracted, said gripping fingers being arranged so as to form a discontinuous annulus which surrounds the screw to be extracted; and
- a control sleeve means, threaded for movement along said rod member, for controlling expansion and contraction of said gripping fingers in accordance with the longitudinal position of said sleeve means along said rod member; said fingers each including a longitudinally tapered tip portion which permits the fingers to be driven into the surface surrounding the head of the screw to be extracted and including means for providing firm gripping of the screw head, said gripping means comprises a plurality of parallel extending gripping ridges formed on inwardly facing side surfaces of each of elongate fingers, said gripping ridges extending along the length of said fingers so as to permit said side surfaces to grip the screw over the area of mutual engagement between said surfaces and the screw.

2. A screw extracting device as claimed in claim 1 wherein said gripping means comprises gripping ridges on said fingers.

3. A screw extracting device as claimed in claim 1 wherein the tips of said fingers are of a chisel-like configuration.

4. A screw extracting device as claimed in claim 1 comprising three said gripping fingers disposed in equispaced relationship around a common longitudinal axis.

5. A screw extracting device as claimed in claim 4 wherein said fingers are formed integrally with said rod member and are biased outwardly away from said longitudinal axis.

6. A screw extracting device as claimed in claim 1 wherein said sleeve means comprises a tubular sleeve, the outer surface of said sleeve being knurled.

7. A method of extracting a screw the head of which is substantially flush with or lies below the surface into which the screw extends, utilizing a device comprising an elongate rod threaded along a portion of a length thereof; a handle located at one end of said rod; a plurality of elongate, longitudinally tapered gripping fingers located at the other end of said rod including a plurality of gripping ridges on inwardly facing side surfaces of each of said fingers along the length thereof for gripping the screw to be extracted; and a sleeve member, threaded for movement along said rod, for controlling opening and closing of said gripping fingers in accordance with the longitudinal position of said sleeve member along said rod, said method comprising:
- applying an impact force to the said one end of said device so as to drive said elongate, longitudinally tapered gripping fingers into said surface in a direction substantially perpendicular to said surface and to a depth such that ridges on said inwardly facing side surfaces of said fingers, will engage the screw when said fingers are closed;
- screwing said sleeve member onto said rod in a direction towards said gripping fingers so as to provide closing of said gripping fingers about the head of the screw; and
- rotating said device to cause unscrewing of the screw.

* * * * *

United States Patent [19]

Kendall

[11] **Patent Number: 4,826,372**

[45] **Date of Patent: May 2, 1989**

[54] **PRE-LOCKED PULL-TYPE BLIND FASTENER**

[75] Inventor: **James W. Kendall**, Huntington Beach, Calif.

[73] Assignee: **Victor Pastushin**, Marina del Rey, Calif.

[21] Appl. No.: **893,582**

[22] Filed: **Aug. 6, 1986**

[51] **Int. Cl.**^{4} **F16B 13/04**

[52] **U.S. Cl.** **411/43**; 411/38; 411/70

[58] **Field of Search** 411/34-38, 411/41, 43, 55, 69, 70

[56] **References Cited**

U.S. PATENT DOCUMENTS

2,038,189	4/1936	Morris	411/34
2,061,628	11/1936	Huck	411/43
2,435,144	1/1948	Kubicki	411/34
2,526,235	10/1950	Huck	411/43
3,148,578	9/1964	Gapp .	
3,178,989	4/1965	Siebol	411/38
3,253,495	3/1966	Orloff .	
4,012,984	3/1977	Matuschek .	
4,127,345	11/1978	Angelosanto .	
4,230,017	10/1980	Angelosanto .	
4,432,679	2/1984	Angelosanto .	

FOREIGN PATENT DOCUMENTS

2151738	7/1985	United Kingdom	411/43

OTHER PUBLICATIONS

Huck Manufacturing Co., Blind Bolt Fastener-Form No. CA. 102/83 3M.

Huck Manufacturing Co., Unimatic Single Action Non-Shifting Blind Rivet System-Form CA110 11-782, Rev. 796M.

Huck Manufacturing Co., Conical Keystone Lock Blind Rivet-Form No. 8-388, Rev. 1-59.

Huck Manufacturing Co., Unimatic Blind Bolt Fastening System-CA 131 5/83.

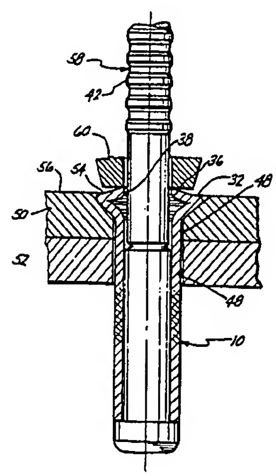
Primary Examiner—Neill Wilson

Attorney, Agent, or Firm—Natan Epstein; William H. Pavitt, Jr.

[57] **ABSTRACT**

A pull-type blind fastener has a pin slideable through a tubular selectively annealed sleeve, the pin having a pin head permanently bonded to a blind side end of the sleeve, a hollow rivet head formed on the opposite end of the sleeve, and a raised abutment on the rivet head engageable by a conventional rivet setting tool. The rivet head collapses under the differential pulling force applied by the setting tool to a condition of reduced aperture for engaging a stop shoulder on the pin thus limiting axial pin travel at a flush breaking position.

33 Claims, 2 Drawing Sheets



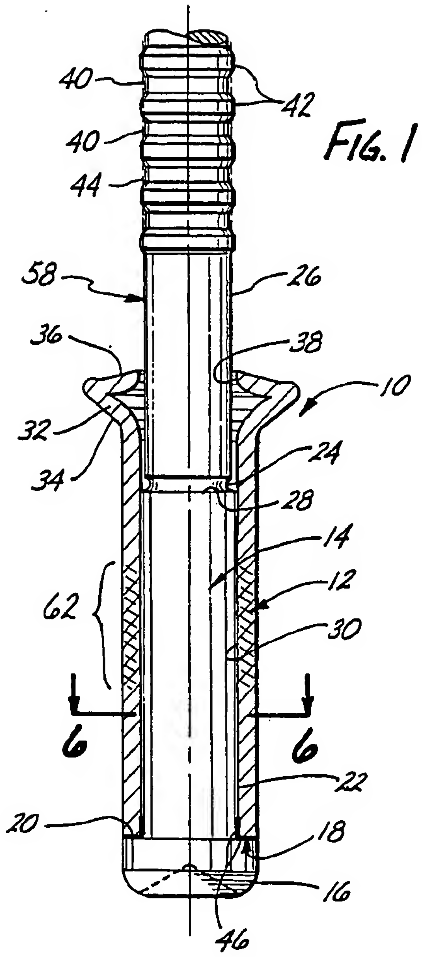


FIG. 1

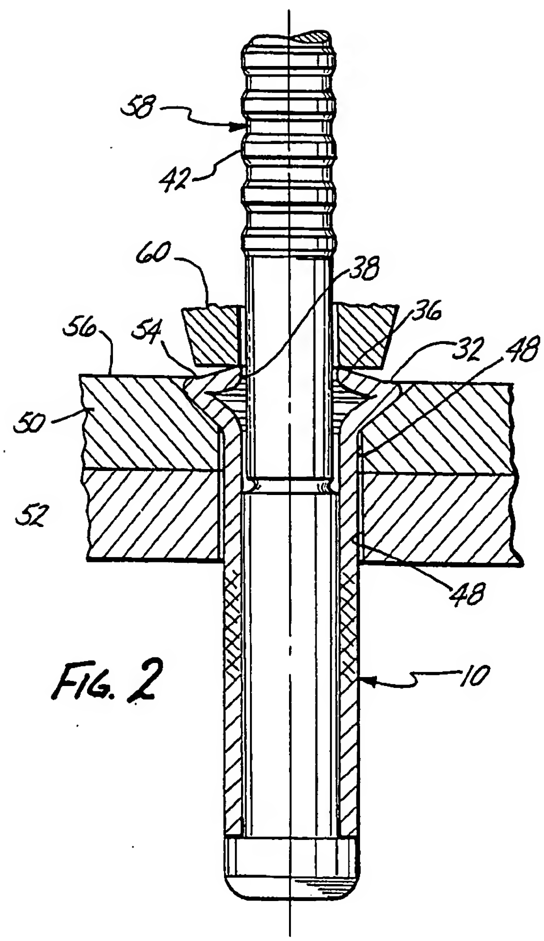


FIG. 2

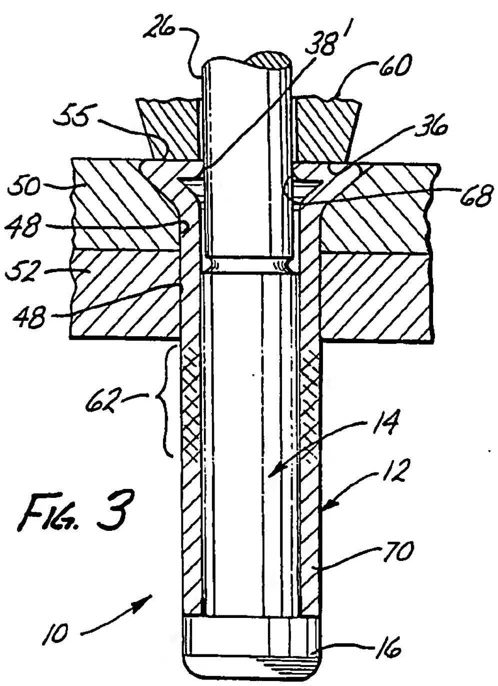
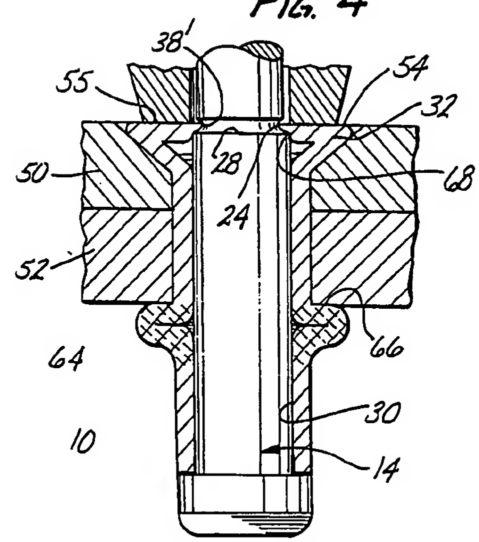


FIG. 3

FIG. 4



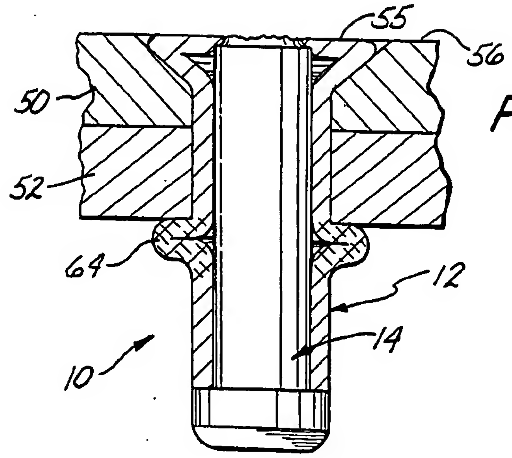


FIG. 5

FIG. 6

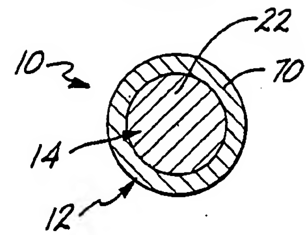


FIG. 7

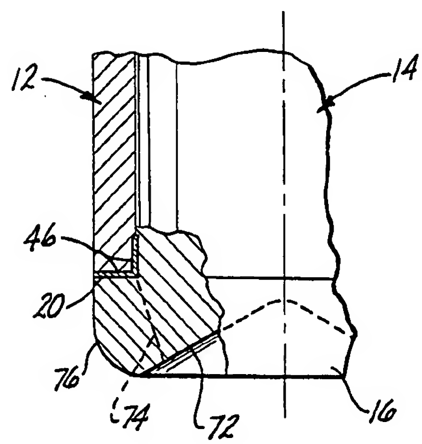
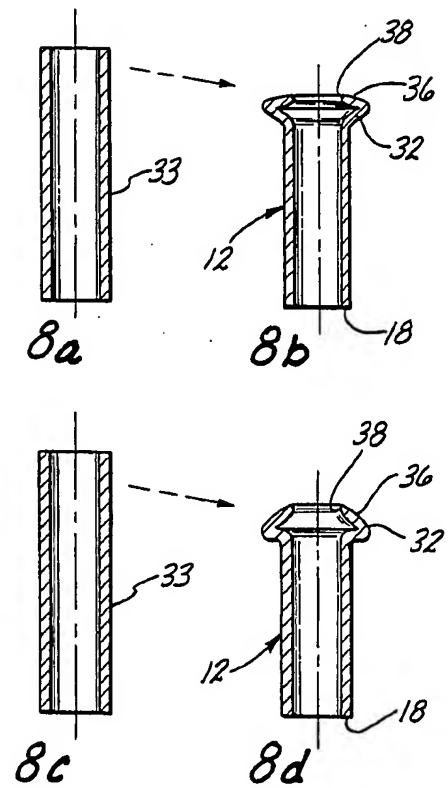


FIG. 8



PRE-LOCKED PULL-TYPE BLIND FASTENER

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention pertains generally to the field of fasteners and is more particularly directed to a pull-type blind fastener of the type having a pin and sleeve wherein the pin and sleeve are pre-locked, i.e. permanently bonded to each other prior to fastener installation.

2. State of the Prior Art

Pull-type blind fasteners have as their primary components a tubular sleeve and a pin axially movable through the sleeve. The pin has a pin head or equivalent element which engages one end of the sleeve. The opposite or free end of the pin extends from the sleeve and typically has a series of pull grooves which permit the pin to be positively gripped within the nose of an installation tool. The fastener is installed by inserting the sleeve in an installation hole formed in the workpiece to be fastened and the tool nose is placed against the outer end of the sleeve with the grooved pin end within the nose. Upon actuation the installation tool applies pulling relative axially compressive load on the sleeve until the sleeve wall buckles to form a bulb or head on the blind side of the workpiece, which remains secured between the blind-side bulb and a rivet head pre-formed on the exposed end of the sleeve. The excess length of the pin is broken off at a break groove flush with the rivet head.

The shear strength of the installed fastener is attributable in large part to the sleeve, but the remaining pin portion does contribute importantly in this respect and installed fastener shear strength is significantly compromised by separation of the pin from the sleeve. Provision is therefore made for retaining the pin within the installed sleeve either by a friction lock in non-critical applications or by a positive mechanical interlock for critical applications such as aircraft frames. In either case the locking of the pin to the sleeve occurs during fastener installation, prior to which the pin portion which remains after installation is not axially fixed to the sleeve.

Many blind fastener designs are known featuring mechanical pin locking as part of the fastener installation procedure. The mechanical locking action is presently achieved either by a separate locking collar element carried on the pin and forced by the installation tool into a locking groove in the pin as exemplified by U.S. Pat. No. 4,012,984, to Matuscheck and Pratt, No. 4,451,189 among many others, or by compressively flowing sleeve material into a locking groove in the pin to create the required mechanical interlock as in Fry et al U.S. Pat. No. 3,292,482 and in Mil-R-007885 rivets. In both cases the need for a locking groove weakens the pin.

Important criteria in fastener performance are the size and strength of the blind side bulb formed and the degree of hole fill achieved by swelling and radial expansion of the sleeve within the workpiece. Existing fastener designs suffer from significant drawbacks in these respects as illustrated by the following examples selected from some of the most popular aerospace blind fasteners currently in use.

In a first type of currently available blind rivet (meeting MIL-R-7885 and NAS1738,39 specifications) blind head formation is accomplished by either a separate compressible element such as the collapsible barrel of

Pratt U.S. Pat. No. 4,541,189 or the integral shear ring used in Matuschek U.S. Pat. No. 4,012,984 among others, the functions of which is to firstly place a compressive load on the blind side sleeve end to initiate fastener hole filling action, and to secondly slide within the exposed blind-side end of the sleeve thereby creating a large bearing blind head. The integral shear ring or separate compressible element yields or collapses axially as necessary to accommodate differences in workpiece thickness within a permissible grip range characteristic of the particular fastener. This yielding allows continued travel of the pin through the sleeve to a point where it engages a mechanical locking element at which point the portion of the pin protruding from the sleeve can be broken off flush with the sleeve head.

Fasteners of this first type perform adequately but suffer from the following disadvantages:

(a) The shear ring integral to the pin or the separate compressible element axially mounted on the pin are tolerance critical and require costly methods of manufacture the expense of which is ultimately borne by the end user.

(b) The fastener installation loads i.e. the magnitude of relative pulling force between the sleeve and the pin of the fastener necessary for blind head formation and to compress the sleeve so that it swells radially to obtain adequate filling action are inordinately high. This results in a need to use dissimilar materials for the sleeve and the pin as exemplified by Gapp, U.S. Pat. No. 3,148,578, the most popular combination of materials being an aluminum sleeve mated with a heat treated, cadmium plated alloy steel pin. By using a stronger pin material than the sleeve material, the pin diameter necessary to axially collapse the sleeve can be kept relatively small in relation to the sleeve cross section. This is desirable because the installed tensile strength of the fastener depends primarily on the sleeve wall thickness which it is therefore desirable to maximize in relation to the pin cross section for a given fastener diameter. Such combination of dissimilar materials carries a weight penalty caused by the relatively heavy steel pin in addition to the corrosion problems associated with dissimilar metals.

A second type of fastener which attempts to overcome the problems of dissimilar materials is disclosed in Orloff U.S. Pat. No. 3,253,495 and such fasteners are available under specifications MS90353/54, MS21140/41, and NAS1919/21. These blind fasteners are characterized in that a variable hardness gradient is created in the sleeve by selectively annealing the blind head formation zone. The annealed sleeve section is softer than the end sections of the sleeve and bulges more readily under axial loading to form the blind head. The selective annealment alone however is not sufficient to allow use of similar pin and sleeve material with a favorable pin/sleeve cross-sectional ratio. These fasteners typically require further weakening of the sleeve by providing an enlarged hole portion in the sleeve so as to reduce the sleeve wall thickness along the annealed section and thereby reduce the installation load necessary to form the blind head in order to make the sleeve operative in combination with pins made of similar material to the sleeve. Sleeves of this type therefore have a stepped inside diameter or a counterbored through hole. This approach allows a relative increase in sleeve wall thickness within the workpiece hole, but the sleeve wall thickness along the blind head formation

zone remains relatively thin compared to the pin diameter in that zone. The pin/sleeve fractional percentage ratio of overall fastener cross sectional area along the bulb formation zone is generally 30/70 while within the workpiece hole where the sleeve through-hole is of smaller diameter the same ratio is approximately 50/50. In these fasteners the blind head is formed by a pin head in external abutment with the blind side sleeve end. The pin head is compressively forced against the end of the sleeve, causing the variable hardness gradient section to bulge outwardly at the blind-side sheet line of the workpiece, forming a large bearing blind head. The pin travels axially through the sleeve compressing the blind sleeve end until the pin engages a mechanical locking element which stops the pin with a break groove in alignment with the sleeve head so that the pin breaks off flush with the sleeve head. The performance trade-off in such fasteners is that while the sleeve section of reduced wall thickness yields readily to the compressive force exerted by the pin head, little or no compressive workpiece hole filling action occurs in the sleeve section of heavier wall thickness. Fasteners of this type (MS 90353/54 and MS 21140/41 type fasteners) are therefore generally referred to as blind bolts since no hole filling action is apparent. A variant of this same basic design is found in NAS1919/21 type blind fasteners in that an additional hole filling feature is included and these latter fasteners are therefore considered to be blind rivets. The hole filling feature consists of an enlarged diameter portion on the pin which is forced or dragged through the sleeve along the reduced through-hole section, extruding and expanding radially outwardly the sleeve as the pin is pulled through. This sleeve expansion is not uniform through the workpiece because the enlarged pin portion or plow does not travel or act on the full length of the sleeve and also because no radial sleeve expansion occurs in the thinner walled counterbored section of the sleeve.

Fasteners of this second group meet all desired functional requirements including the use of similar pin and sleeve materials, but retain the following disadvantages:

(a) The stepped inside diameter or counter-bore of the sleeve is tolerance critical, both from a size and concentricity standpoint and can only be formed from the sleeve blind end in the manufacture of the sleeve. The necessity for a thin walled section at the blind end of the sleeve to maintain low blind head formation loads compounds the tolerance criticality of the fastener structure. Failure to maintain the necessary tolerances results in frequent improper blind head formations ("tulip bulbs") which require costly remake or rework activities.

(b) The blind rivet fasteners of the second group variant having the aforementioned additional hole filling feature require greater blind-side clearance because the pin extends out of the sleeve to a greater extent due to the enlarged extrusion element provided on the pin. Also, the stepped inside diameter of the sleeve causes variable hole fill so that the hole fill is not uniform through the full length of the installation hole in the workpiece. Such variable hole fill can also head to improper blind head formations.

(c) The blind side heads formed by these rivets are particularly weak because their formation load must be safely below any other fastener installation load, i.e. the mechanical lock engagement loads between the pin and the sleeve (with or without frictional forces therebetween taken into account) and the pin breakoff load at the breakneck.

The outer sleeve diameter of a given fastener, and therefore the combined sleeve wall and pin cross sectional areas, is selected according to the requirements of the particular application and is set by the installation hole in the workpiece. In other words, the overal fastener or sleeve diameter is largely determined by factors external to the fastener itself. The relative proportions of the overall fastener cross-section attributable to the sleeve wall and to the pin however are a function of fastener design. For a given outer sleeve diameter, it is generally desirable to maximize the sleeve wall thickness in order to maximize installed fastener tensile strength. However, sleeve wall thickness can only be increased at the expense of a reduction in the pin diameter. As the sleeve wall thickness is increased, it offers proportionally greater resistance to axial compression by the pin and thus a greater installation load is needed between the pin and the sleeve. As the pin diameter is decreased to obtain a heavier sleeve wall, the strength of the pin is proportionally diminished until a pin diameter is reached where the pin would break prematurely under the required installation load. In prior art fasteners pin strength has been compromised by the need to provide various features, structures and grooves such as locking grooves, steps, etc. on the pin, of which the pin break groove must necessarily be the smallest so as to prevent the pin from breaking at an improper point. At the same time, the pin break groove diameter sets an upper limit for the pulling force which can be applied to the pin during fastener installation, which in turn limits sleeve wall thickness, the size and strength of the blind heads, and the degree and extent of hole fill achieved.

Further, because of the internal steps, counterbores and other features required on sleeves of prior art fasteners it is conventional in the art to fabricate the sleeves from solid wire stock by a progressive cold forming process which makes it very difficult to maintain close tolerances in uniformity of sleeve wall thickness, concentricity of the sleeve bore and squareness of the blind side sleeve end surface against which bears the pin head. All these are factors which affect the uniformity and reliability of the joints obtained with the fasteners and close control over the same is highly desirable.

A continuing need therefore exists for fasteners having superior pin strength in relation to maximum pin diameter so that heavier sleeves can be compressed for a given pin diameter resulting in stronger and larger blind-side heads, improved and more uniform hole fill, and greater installed fastener strength while using similar pin and sleeve materials. Such an improved fastener should be simple and inexpensive to manufacture with a minimum number of parts. It is further desirable to make the fastener parts from raw materials and by manufacturing processes which minimize tolerance criticality problems.

SUMMARY OF THE INVENTION

The present invention addresses these and other shortcomings of prior art fasteners by providing a pulltype blind fastener having a sleeve of continuous inner diameter with a sleeve head formed at one end, and a pin axially slideable through the sleeve but permanently bonded to the blind-side end of the sleeve. Unlike previously known pulltype fasteners, the pin is pre-locked to the sleeve prior to installation to thereby eliminate the

need for either a locking collar element or a locking groove on the pin. As a result, the pin break groove can be enlarged in diameter thereby increasing the maximum installation load which can be applied to the pin. The sleeve head is deformable and folds inwardly upon application of the relative pulling force so as to engage a stop element on the pin thereby limiting axial travel of the pin through the sleeve.

The pin shank includes a first shank section adjacent to the pre-locked pin end having a first diameter substantially equal to the internal diameter of the sleeve, and a second shank section of reduced diameter which extends through the bore in the sleeve head to protrude exteriorly to the sleeve. Annular lands are formed on the protruding shank portion defining therebetween a series of pull grooves on the second shank section. The land crests have a diameter intermediate the first and second shank section diameters and preferably equal to the diameter of the first shank section. The pull groove diameter may be only slightly smaller than the diameter of the second shank section so as not to substantially weaken the pin. An annular stop shoulder is defined at the transition between the first and second pin shank sections and a pin break groove or breakneck is defined on the second shank section preferably immediately adjacent the stop shoulder. The breakneck is sized so as to be the weakest point along the pin shank, but because of the small depth of the pull grooves permitted by the use of annular lands and the absence of other grooves, it is possible to minimize the depth of the breakneck, and thus retain strength considerably in excess of what has been possible in prior art fastener pins of comparable installed diameter. The diameter of the first pin shank section is the installed diameter of the pin since the second shank section is broken off at the pin break groove once the fastener has been installed.

In a presently preferred embodiment the pin is provided with an enlarged pin head which is exterior to the sleeve and abuts against the blind-side end of the sleeve so as to lock the pin against axial travel towards the sleeve head. The pin is pre-locked to the sleeve by metallurgically bonding the pin head to the blind-side sleeve end, thus permanently locking the pin head against withdrawal and separation from the sleeve. The sleeve head has a generally conical centrally apertured end wall coaxial with the sleeve and forming an abutment for the nose of the fastener installation tool. The pin shank including the annular lands defining the pull grooves pass through the sleeve head aperture in its normal condition. When the protruding pull-grooved portion of the pin shank is engaged by the installation tool, the tool nose bears against the abutment which yields under the installation loading and folds to a condition where the central opening in the sleeve head is reduced in aperture for engaging the stop shoulder on the pin to thus limit axial travel of the pin through the sleeve with the break groove aligned for flush pin breaking.

A hardness gradient is created in an intermediate section of the sleeve wall in relation to the hardness of the end portions of the sleeve by selectively annealing the sleeve wall in the manner taught by Orloff in U.S. Pat. No. 3,253,495. Upon sufficient axial compressive loading of the sleeve between the sleeve head and the blind-side end by the installation tool, the sleeve collapses axially and expands preferentially within the softer annealed section to form the blind-side bulb. The bulb forming process tends to reverse the weakening effect of the annealing process and to restore the treated section of sleeve wall at least partially to its original hardness, thereby improving the strength of the formed bulb. Further, the annealed sleeve section can collapse axially to a greater or lesser extent and within limits permits a range of operative fastener grips so as to accommodate variations in workpiece thicknesses for a particular fastener size.

A "flagging" feature for spotting improper fastener installations may be incorporated by constructing and configuring the pin head such that it cannot alone withstand the pulling force applied to the pin during fastener installation, but will withstand the fastener installation load in cooperation with the pre-locking bond between the pin head and the sleeve. Thus, in the event that the pre-locking bond fails to meet minimum strength criteria in a particular fastener, the pin head will fail structurally and allow the pin to travel axially through the sleeve beyond a flush breaking position so that a portion of the first shank section will protrude through the sleeve head providing an immediate visual indication or "flag" of a substandard joint.

A still further benefit derived from the novel fastener design is that the annular pre-locking bond between the pin head and the sleeve seals the sleeve bore against internal fluid flow through the fastener. The installed fastener joint can therefore be made completely fluid-tight by provision of a simple external seal between the sleeve and the workpiece, such as an O-ring, a resilient washer or jacket about the sleeve, or a layer of liquid sealing compound applied over the fastener sleeve prior to its insertion into the workpiece installation hole. Fluid-tight blind rivets are highly desirable particularly in the construction of so-called wet aircraft wings where the hollow wing also serves as a fuel tank. In the past, attempts to construct fluid-tight blind rivets have been frequently frustrated because of internal leakage through the fastener sleeve bore, a problem overcome by the present invention.

The present fastener design optimizes pin strength for a given installed pin diameter, thus permitting more favorable pin-to-sleeve cross sectional area ratios, resulting in improved installed fastener strength. The enhanced installation load tolerance of the pin permits the use of similar pin materials for both sleeve and pin, eliminating the aforementioned problems associated with the use of dissimilar metals. The lack of internal features and smooth bore allows the sleeve to be manufactured from continuous wall thickness constant diameter tubing stock ensuring a high degree of uniformity in sleeve characteristics, particularly in terms of sleeve wall thickness and concentricity which reduces the likelihood of improper blind head formations common in prior art fasteners. Sleeve blanks are prepared by cutting off tubing sections from greater lengths of tubing stock and the sleeve head is readily formed as by cold forming on the sleeve blanks. The pin is then inserted through and bonded to the fabricated sleeve.

These and other advantages of the present invention will be better understood from the following detailed description of the preferred embodiment considered with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal view partly in section of a blind fastener according to the present invention.

FIG. 2 is a similar view of the fastener of FIG. 1 disposed within aligned openings in a workpiece to be

fastened, and showing the fastener engaged by the nose of an installation tool preliminary to setting of the fastener.

FIG. 3 shows the fastener of FIG. 2 in a first intermediate stage of the setting process prior to formation of the blind head.

FIG. 4 shows the fastener of FIG. 3 in a more advanced intermediate stage of the setting process wherein the blind head has formed but prior to pin break off.

FIG. 5 shows the fastener of FIG. 1 fully installed.

FIG. 6 is an axial cross-section of the fastener taken along line A—A in FIG. 1.

FIG. 7 is an enlarged view of the fastener portion enclosed in circle B in FIG. 1 showing the pre-locking bond between the pin head and the sleeve.

FIG. 8*b* shows a sleeve with a formed countersink style head for a fastener according to this invention fabricated from the sleeve blank shown in FIG. 8*a*.

FIG. 8*d* shows a sleeve with a formed protruding style sleeve head for a fastener according to this invention fabricated from the sleeve blank shown in FIG. 8c.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference to the drawings, FIG. 1 shows a blind fastener 10 constructed according to the present invention. The fastener 10 includes a tubular sleeve 12 and a pin 14 disposed axially through the sleeve. The pin 14 includes a generally cylindrical pin head 16 external to the sleeve 12 and in abutting contact with the blind-side end 18 of the sleeve. The pin head 16 has an annular undersurface 20 which defines a substantially square shoulder with the pin shank. The blind-side sleeve end 18 is cut square to the longitudinal axis of the sleeve so as to form an annular transverse end surface perpendicular to the sleeve axis and opposing the pin head undersurface 20. The shank of the pin 14 includes a first shank section 22 which has a diameter substantially equal to the internal diameter of the sleeve 12, or just slightly undersized thereto so as to make a close sliding fit with the sleeve. Shank section 22 is immediately adjacent to the pin head 16 and terminates at a breakneck groove 24. A second pin shank section 26 extends from the breakneck 24 to a free outer end (not shown) of the pin 14. The second shank section 26 has a diameter reduced in relation to the diameter of first shank section 22. The diametral transition between the two shank sections forms an annular substantially square stop shoulder 28 at the end of shank section 22 adjacent to the pin break groove 24.

The sleeve has a hollow clamshell shaped sleeve head 32 formed at its outer end. Between the blind-side end 18 and the sleeve head, the sleeve 12 is of uniform outer diameter and has a smooth internal through-bore 30 of uniform diameter. In the illustrated embodiment the sleeve head 32 is of the countersink style and has a conical undersurface 34. The sleeve head terminates in an outwardly facing end wall defining a generally conical truncated raised abutment 36 centrally apertured by a sleeve head through-bore 38 coaxial with the sleeve bore 30.

The first shank section 22, the breakneck groove 24 and an inner portion of the second shank section are contained within the sleeve 12 while the second shank section 26 of reduced diameter extends through the sleeve head bore 38 and terminates exteriorly to the sleeve 12. A series of annular lands 42 and pull grooves 40 are roll formed on the exterior portion 58 of the second shank section 26. Roll forming results in metal displacement such that when a thread, annular groove or the like is rolled into the part, the crest of the annular land grows in diameter by approximately the same amount as the root or groove diameter decreases. It is therefore well understood in the art that rolling is done in a pitch diameter 44 (indicated in dotted lining in FIG. 1) which is approxiamtely one groove height less than the desired finished outside diameter of the rolled section, i.e. the land diameter 42.

In the fastener of FIG. 1, the sleeve bore 30, the first pin shank section 22, the sleeve head bore 38 and the pull groove lands 42 are all substantially equal in diameter. The portion of the second pin shank section 26 lying between the pull grooved portion and the breakneck 24 is smaller in diameter than the sleeve head bore 38 and equal to the pull groove pitch diameter 44.

The fastener is assembled by inserting the pin 14 into the blind-side end of the sleeve 12 until the pin head 16 abuts against the sleeve. In an initial or normal condition of the fastener 10 before installation, the rim of the sleeve head bore 38 makes a near net fit with the pull groove lands 42 i.e. allows the pull grooved portion of the pin to just past through the sleeve head without diametrical interference. Once the pin is assembled to the sleeve, the sleeve and the pin are permanently joined together by an annular pre-locking bond 46 between the pin head undersurface 20 and the blindside end surface of the sleeve as indicated in FIG. 1. The pre-locking bond may be formed by brazing, soldering, or other suitable metallurgical process capable of forming a high-strength bond with the particular pin and sleeve materials used. For steel alloy materials silver brazing has been found suitable. The pre-locking bond 46 is annular, extending the full circumference of the sleeve end surface and annular pin head undersurface 20, and as better seen in FIG. 7 further extends axially a small distance into the space between the pin shank and the sleeve. The pre-locking bond thus has a butt end component and an axial component, the latter being primarily responsible for cooperating with the pin head in resisting the fastener installation load. Molten solder is directed into the sleeve bore for forming the axial component of the bond by a slight chamfer or similar shape at the end of the sleeve bore which can be easily and conveniently formed by appropriately shaping the bottom stop which supports the sleeve blank during cold formation of the sleeve head. the bond 46 also makes a fluid tight seal between the pin head 16 and the sleeve 12, closing the sleeve bore 30 against fluid flow.

An intermediate section 62 of sleeve 12 is selectively annealed to create a hardness gradient between the sleeve ends. The hardness gradient includes a zone of reduced hardness of the sleeve material in relation to the untreated end portions of the sleeves. Thus, the hardness of the sleeve material is uniform along the undertreated end sections of the sleeve and falls off towards a minimum hardness within the annealed section 62. For a more detailed explanation of the sleeve annealment and of the hardness gradient obtained thereby reference is made to U.S. Patent 3,253,495 issued to Orloff.

Installation of the fastener 10 to make a joint in a workpiece is shown in the sequence comprising FIGS. 2-5. Turning to FIG. 2, the fastener 10 is shown inserted into aligned workpiece openings 48 defined in juxtaposed workpiece panels 50 and 52 to be joined by

means of fastener 10. The hole 48 in outer panel 50 is shaped to define a conical seat for the undersurface 34 of the sleeve head 32 such that the top 54 of the sleeve head 32 is flush with the outer surface 56 of workpiece panel 50. The conical abutment 36 projects from the sleeve head top 54 and terminates at the circular edge of bore 38 above the panel surface 56.

The outer pull-grooved portion 58 of the pin stem is engaged by the nosepiece of a conventional single action, pull-type installation tool with the driving anvil 60 of the nosepiece bearing against the uppermost end of the raised abutment 36, i.e. against the rim surrounding the sleeve head bore 38. In the initial condition of FIG. 2, the sleeve head 32 only partially contacts the anvil 60 due to the raised abutment 36. While only the nose portion of the installation tool is illustrated, its construction, function and operation are well known in the art. In general, the projecting end 58 of the pin is engaged within the installation tool which, when actuated, pulls axially on the pin while applying a reaction force against the sleeve head 32 through the nosepiece anvil 60.

Turning to FIG. 3 which illustrates a first intermediate stage of the fastener installation, relative pulling force has been applied by the installation tool between the pin and the sleeve head, causing the nose anvil 60 to react against and push inwardly on the raised abutment 36, folding and flattening the raised abutment to an installed condition where the sleeve head 32 has a substantially flat outer or end face 55 flush with the workpiece face 56. Upon flattening of the conical abutment the sleeve head bore 38 is reduced from its normal aperture to a smaller diameter 38' substantially equal to the diameter of second pin shank section 26 but in any event smaller than the diameter of first pin shank section 22. At this stage, the relative pulling force applied between the pin and the sleeve is squeezed between the pin head 16 and the nosepiece 60. The compressive axial loading of the sleeve 12 causes the sleeve wall 70 to begin to swell diametrically and to fill the openings 48 in the workpiece panels as the sleeve expands diametrically.

As the relative pulling force continues, the compressive force on the sleeve causes the sleeve wall in the softer selectively annealed section 62 to buckle radially outwardly and form a large bulbed blind head 64 as shown in FIG. 4. The bulb 64 so obtained has a relatively large annular bearing surface 66 which bears against the blind-side of workpiece panel 52. The axial collapse of the sleeve 12 attendant to blind head formation allows the pin 14 to travel axially through the portion of the sleeve disposed within the workpiece openings 48 and through the sleeve head bore 38' until the stop shoulder 28 comes into contact with the edge 68 of the reduced sleeve head bore 38', mechanically stopping further axial travel of the pin through the sleeve bore 30 with the pin break groove 24 positioned for proper flush breaking with the outer face 55 of the sleeve head 32.

Continued pulling force applied by the installation tool breaks the pin 14 at the groove 24 flush with both the sleeve head and the outer surface 56 of the workpiece 50 as shown in FIG. 5, which shows the fastener in its final installed or set condition. The section 22 of the pin which remains within the sleeve is locked against withdrawal and separation from the sleeve by the pre-locking bond 46 between the pin head and the sleeve.

With reference to FIG. 6, the relative cross sectional areas of the sleeve wall 70 and pin shank section 22 may be compared in relation to the overall fastener cross sectional area, i.e. the area encompassed within the outer sleeve circumference. It has been determined for the fastener 10 of this invention, using similar materials for the pin and the sleeve and taking into account the weakening of the sleeve 12 by partial and selective annealement, that the optimum sleeve wall 70 cross sectional thickness is between 45% and 55% of overall fastener cross sectional area with a presently preferred figure of 50% for optimal balance of the relative strengths of the pin 14 and the sleeve 12.

For a given installed pin diameter, i.e. the diameter of pin section 22, the strength of the pin 14 is limited by the weakest point along the pin between the head 16 and the pull grooves 40. This weakest point necessarily must be at the pin break groove 24. The breakneck diameter therefore determines the maximum installation load which can be carried by the pin 14. In order to maximize the possible installation load for a given installed pin diameter it is therefore desirable to maximize the pin diameter at the breakneck. This in turn requires that the depth of the pull grooves be minimized since the pull groove diameter must be greater than the breakneck diameter. This objective is attained by roll forming the pull grooves in the manner already described, rather than machining or cutting the pull grooves into the pin section 26 which would result in a smaller pull groove diameter and consequently a still smaller breakneck diameter. Thus, the pin 14 is firstly fabricated with the shank section 26 diameter (the pitch diameter) approximately one pull groove depth less than the shank section 22, the pull groove dept being measured between the crest of pull groove land 42 and the actual bottom of the pull grooves 40. Upon subsequent rolling of the pull grooves themselves, the lands 42 are formed which have a diameter one pull groove depth greater than the pitch diameter 44, the net diametral difference between the bottoms of pull grooves 40 and crests of lands 42 being two pull groove depths. In the present fastener the reduction in diameter of the pin shank section 26 has been found optimum at 0.003 inches to 0.005 inches less than the sleeve inner diameter 30, with a preferred figure of approximately 0.004 inches for fastener diameters between 3/32 and ⅛ inches. It is anticipated that larger size fasteners would require appropriate modification in this respect. The aforesaid difference of some 0.004 inches is also the diametral difference between pin shank sections 22 and 26 and is twice the radial width of the stop shoulder 28. It must be appreciated that the step element at the shoulder 28 is not extraneously introduced for the sole purpose of stopping axial travel of the pin. Rather it is a necessary transition dictated by the aforementioned desirability to roll-form the pull grooves. Since this shoulder 28 is inherently created by these other requirements, it is advantageously used in the present fastener as a means for stopping axial travel of the pin with the breakneck flush to the sleeve head in cooperation with the deformable sleeve head 32.

It is presently preferred to make both the sleeve 12 and pin 14 of similar steel alloys, and to make the pin head/sleeve bond 46 by silver brazing. The sleeve head 32 is manufactured by cold forming continuous wall thickness tubing with a punch and dye in a conventional manner. The sleeve head undersurface 34 may have a conventional 100 degree included angle countersink, and the raised abutment 36 may be a conical end wall

portion rising at an angle of between 15 to 30 degrees with a 23 degree angle being preferred relative to a plane transverse to the sleeve axis. The diameter of the breakneck 24 is approximately 85% of the installed pin diameter, a figure which substantially improves over breakneck sizes of prior art fasteners. This relatively large breakneck diameter allows use of a pin of relatively small installed diameter because the load bearing strength of the pin is not as greatly diminished by the breakneck groove as has been previously the case. The relatively small installed diameter of the pin permits a corresponding increase in the sleeve wall thickness, permitting the use of a more rugged sleeve which is successfully axially collapsed by a relatively small pin.

A thicker sleeve wall is not only desirable for improved installed fastener strength but it is conducive to improved compressive hole fill and proper blind head formations. Further, a heavy sleeve wall increases the area of contact between the blind-side end surface of the sleeve 12 and the undersurface 20 of the pin head, providing a more substantial bearing face of improved compressive hole filling action. Good hole filling action is further promoted by the ability to use seamless continuous wall thickness tubing as the starting material in the manufacture of the sleeve, because of the characteristic consistency of size, thickness and concentricity of such tubing. The uniformity of the seamless tubing coupled with the large bearing end surface of the sleeve is also beneficial in obtaining optimum blind head shapes and avoiding improper head forms such as tulip bulbs. Proper blind head formations are still further encouraged by the positive pre-locking bond between the sleeve end and the pin undersurface.

In certain applications it is highly desirable that the fastener feature a self-inspecting or "flagging" device. The term "flagging" is well understood in the art to define a condition whereby the fastener will selectively malfunction in the event of improper fastener use, selection, or quality problem associated with a specific fastener installation which is not otherwise apparent to the installer. The fastener if properly installed will show a pin broken off substantially flush with the outer face of the rivet head as shown in FIG. 5. If particular fastener is set with the pin broken in a position which is not substantially flush, the particular fastener should be considered and improper fastener installation and should be removed and replaced. These are well known and accepted practices in the art, and the range of acceptable and unacceptable installed pin positions are specified for each fastener size within a family of fasteners.

Following installation of the present fastener the pin is retained to the sleeve of the unit primarily or solely by the pre-locking bond 46. Should this bond fail or be of substandard strength. the defect is not discernible to the installer since it is hiden on the blind-side of the workpiece. It is therefore desirable to provide a self-testing feature for testing the integrity of the pin pre-locking bond 46 in each installed fastener. Such a feature can be incorporated in the present fastener by configuring and dimensioning the pin head 16 such that it has an axial shearing strength which is approximately 75% of the installation load required to compressively form the sleeve blind head 64. The pin head/sleeve bond 46 is then selected to have an axial shearing strength which when added to the pin head axial shear strength, the combined strengths will suffice to prevent shearing of the pin head and to properly form the blind head 64.

Thus, if in a particular fastener the pin head/sleeve bond 46, and particularly the axial component of the bond 46, should fail to meet the required shear strength characteristics, the pin head will yield axially under the installation load because without an adequate bond 46 the pin head alone has insufficient strength to transmit the compressive forces to the blind-side end of the sleeve so as to form the blind head. The pin head thus fails structurally, allowing the pin 14 to travel axially through the sleeve bore 30 and through the sleeve head bore 38' even though the sleeve head 32 has folded inwardly and the diameter of the sleeve head bore is reduced. In the absence of a positive interlock between the pin head and blind-side sleeve end the installation load applied between the pin and the sleeve head by the installation tool is insufficient to force the enlarged diameter of the stop shoulder 28 through the reduced diameter of the sleeve head bore 38'. The result is that the breakneck 24 moves out of the sleeve head 32 beyond the workpiece outer surface 56 and the installed pin breaks in a position which is substantially beyond flush. This condition is readily apparent visually or otherwise and is indicative of an improper fastener joint requiring replacement. The shear strength of the pin head 16 can be limited in a variety of ways. One approach is suggested in FIG. 7 where the pin head strength has been adjusted by provision of a conical dimple 72 in the end surface of the pin head. It is anticipated that the most likely failure mode is by shearing along dotted line 74. The pin head shear resistance can also be adjusted by varying the axial thickness of the radial shoulder of the pin head abutting against the sleeve, or by varying the curvature of the pin head shoulder 76, or by a combination of these methods.

The fastener structure disclosed herein can be manufactured by more efficient and economic use of materials than has been possible in the past. Both the pin and the sleeve can be formed of similar material and with little or no loss of material due to costly and waistful drilling or other metal cutting operations. Further, the consistency and uniformity of dimensional tolerances and concentricity made possible by use of continuous wall thickness tubing stock and the optimized balance of relative cross-sectional pin and sleeve wall areas made possible by the novel pin structure and cooperation with the deformable sleeve head produces a simple, reliable and strong blind fastener which can be installed with either single action or double action conventional blind rivet setting tools.

As may be seen FIGS. 8*b* and 8*d* the concept of a deformable sleeve head is not limited to a particular style of head. FIG. 8*b* shows a countersink style head while FIG. 8*d* illustrates the novel concept adapted to a protruding head style. These and still other head styles can be formed on sleeve blanks 33 shown in FIGS. 8*a* and 8*c* respectively which are sections of cylindrical tubing of continuous wall thickness and constant diameter cut from longer lengths of seamless tubing stock.

While the pre-locking feature enables a substantial advance over the prior art and is of major importance to the novel blind fastener here disclosed, it should also be understood that in less critical fastener applications it may be possible and advantageous to omit the pre-locking bond between the pin and the sleeve without otherwise altering the fastener structure which remains operative provided the pin head is constructed so as to alone withstand the installation load. In such a simplified, lower cost embodiment the pin is not positively retained

in the installed fastener and reliance is placed only on the sleeve for integrity of the joint.

While a preferred embodiment of the invention has been shown and illustrated for purposes of explanation and clarity, it must be understood that still other changes, modifications and substitutions to the described embodiment can be made by those possessed of ordinary skill in the art without departing from the spirit and scope of the present invention which is defined only by the following claims.

What is claimed is:

1. A pull-type blind fastener suitable for installation with a single-action riveting tool comprising: a tubular sleeve having a blind side end and an opposite head end, a pin disposed slidably axially through said sleeve and projecting from said head end, said pin being permanently bonded to said blind side sleeve end for collapsing the sleeve upon application of sufficient differential pulling force between said projecting pin and the head end of said sleeve thereby to form a bulb on said sleeve;
   said sleeve being deformable by said relative pulling force prior to said bulb formation to a condition engageable with stop means on said pin for limiting axial travel of said pin through said sleeve in response to said differential pulling force, said sleeve initially being apertured to pass said stop means.

2. The fastener of claim 1 wherein both said pin and said sleeve are metallic and said pin is metallurgically bonded to said blind side end.

3. The fastener of claim 1 wherein said sleeve has an annealed intermediate section which collapses axially and bulges preferentially to form a blind-side bulb.

4. A pull-type blind fastener comprising: a tubular metallic sleeve having a blind side end and an opposite head end, a metallic pin disposed slidably axially through said sleeve and projecting from said head end, said pin being permanently metallurgically bonded to said blind side sleeve end for collapsing the sleeve upon application of sufficient differential pulling force between said projecting pin and the head end of said sleeve, said sleeve having an annealed intermediate section which collapses axially and bulges preferentially to form a blind-side bulb, stop means on said pin, and a head on said sleeve deformable by application of said relative pulling force to a condition engageable with said stop means for limiting axial travel of said pin through said sleeve in response to said differential pulling force.

5. A pull-type blind fastener comprising:
   a tubular sleeve including a sleeve head with a raised abutment formed integrally thereon;
   a pin axially slidable through said sleeve, said pin engaging said sleeve for axially collapsing the sleeve upon application of sufficient relative pulling force between the opposite free end of said pin and said raised abutment on said sleeve head;
   stop means on said pin;
   annular lands near said free pin end defining a series of pull grooves;
   said sleeve head being initially apertured for passing said annular lands and said stop means, said head being deformable by said relative pulling force to an installed condition of reduced aperture wherein axial movement of the pin through the sleeve is stopped by engagement of said stop means with said deformed head.

6. The fastener of claim 5 wherein said pin includes a pin head engaging a blind side end of said sleeve, and prelocking bond means permanently locking said pin head to said sleeve against withdrawal therefrom.

7. The fastener of claim 6 wherein said pin head is designed to fail structurally upon application of said differential pulling force in the event said pre-locking bond fails to meet minimum strength criteria and thereby allow said pin to be drawn through said sleeve beyond engagement of said stop means to a flagging installed position visually indicatve of a substandard pre-locking bond.

8. A pull-type blind fastener comprising:
   a tubular sleeve having a head structure integral with said sleeve; and
   a pin axially slideable through said sleeve and locked at one end to said sleeve for axially collapsing said sleeve upon application of relative pulling force between a free end of said pin and said head, said head being deformable prior to said axial collapse by said relative pulling force for engaging stop means provided on said pin so as to limit axial travel of said pin through said sleeve.

9. The fastener of claim 8 further comprising prelocking bond means permanently securing said pin against withdrawal from said sleeve.

10. The fastener of claim 9 further comprising a pin head on said pin in abutment with said one sleeve end for locking said pin against axial movement through the sleeve towards said head structure, and flagging means for visually indicating a substandard pre-locking bond in an installed fastener.

11. A pull-type blind fastener comprising:
   a tubular sleeve having a blind-side end and a sleeve head formed at its opposite end, said rivet head having a conical outer abutment defining a sleeve head bore;
   a pin including a pin shank extending slideably axially through said sleeve and having a pin head in abutment with said blind-side sleeve end for locking said pin against axial movement through the sleeve towards said sleeve head, said pin stem having a first shank section of a first diameter adjacent said pin head and a second stem section of reduced diameter extending through said sleeve head to the exterior of said sleeve, a plurality of pull grooves between annular lands on second stem section exteriorly to said sleeve, a break groove between said first and second stem sections and a stop shoulder at the end of said first stem section adjacent said groove;
   said sleeve head bore having a normal diameter admitting passage of said annular lands and said stop shoulder through said sleeve head such that said pin may be inserted into said sleeve from the blind-side end thereof, said sleeve head being deformable to an installed condition, upon application of relative axial pulling force between the pin and the rivet head so as to axially collapse said sleeve, the diameter of said bore in said installed condition being reduced to less than said first diameter thereby to engage said stop shoulder at said sleeve head for limiting axial movement of said pin through said sleeve with said break groove in predetermined relationship with said rivet head.

12. A pull-type blind fastener comprising:
   a tubular sleeve having a blind-side end, a hollow clamshell sleeve head including an undersurface portion and a generally conical raised abutment

formed on its opposite end, and an intermediate sleeve portion of reduced hardness;

a pin disposed axially through said sleeve, said pin having a pin head in abutment with said blind-side sleeve end so as to lock the pin against axial movement through the sleeve towards said head end, a first pin shank section connected to said pin head and having an outer diameter substantially equal to the inner diameter of said sleeve, and a second pin shank section of lesser diameter than said first section extending through an opening defined by said raised abutment in said sleeve head such that a portion of said second shank section is external to said sleeve;

a plurality of pull grooves on said external shank portion defined between annular lands of diameter greater than said second shank section;

a stop shoulder and a breakneck between said first and second shank sections, said sleeve head opening having a normal diameter greater than that of said annular lands and said stop shoulder so as to permit insertion of said pin through said sleeve from said blind-side end;

said raised abutment being deformable from a normal to a relatively flattened installed condition upon application of relative pulling force between said pull grooved external shank portion and said raised abutment sufficient to axially collapse said sleeve by pulling the pin partially through the sleeve so as to form a bulbed head on the sleeve within said portion of reduced hardness, said head opening being reduced in said installed condition prior to formation of said bulbed head to a diameter lesser than that of said stop shoulder thereby to stop axial displacement of said pin through said sleeve with said breakneck in substantially flush relationship to said sleeve head by engagement of said stop shoulder with the deformed abutment, whereby the installed pin shank has a continuous diameter substantially equal to the sleeve inside diameter.

13. The fastener of claim **12** wherein said pin head is pre-locked by a permanent bond to said blind-side sleeve end for retaining the pin against separation from the sleeve.

14. The fastener of claim **13** wherein said pin head is constructed and configured to fail structurally upon application of said relative pulling force in the event said bond fails to meet minimum strength criteria upon application of said sufficient relative pulling force thereby allowing the pin to be drawn through the sleeve beyond said flush relationship as a visual indicator of a substandard bond.

15. The fastener of claim **12** wherein said sleeve portion of reduced hardness is a selectively annealed sleeve portion intermediate two sleeve end sections of greater hardness.

16. The fastener of claim **12** wherein said sleeve is a length of continuous wall thickness cylindrical tubing of smooth internal bore between said blind-side end and said sleeve head.

17. The fastener of claim **16** wherein said head is cold formed on a length of continuous wall thickness constant diameter tubing.

18. The fastener of claim **12** wherein said sleeve and said pin are both made of substantially similar material.

19. The fastener of claim **12** wherein said sleeve and said pin are made of substantially similar metallic material.

20. The fastener of claim **12** wherein both said sleeve and said pin are made of steel.

21. The fastener of claim **12** wherein both said sleeve and said pin are made of aluminum.

22. The fastener of claim **13** wherein said pre-locking bond is a metallurgical bond.

23. The fastener of claim **13** wherein said bond alone is insufficient to lock said pin to said blind-side sleeve end against said sufficient relative pulling force without substantial resistance of said pin head against said blind-side sleeve end.

24. The fastener of claim **12** wherein said annular lands have a diameter substantially equal to that of said first shank section.

25. The fastener of claim **12** wherein the cross sectional area of said first pin shank section is less than 60 percent of the total cross sectional area encompassed by the sleeve circumference whereby a relatively heavy sleeve is axially collapsed by a relatively small pin.

26. The fastener of claim **12** wherein the diameter of said first shank section is at least equal to that of said annular lands and the diameter of said second shank section is slightly undersized to both said first shank section and said annular lands, said normal head opening diameter making a substantially close fit with said annular lands and reducing to an installed diameter smaller than the diameter of said first shank section.

27. The fastener of claim **26** wherein said breakneck has a diameter in excess of 70% of said first shank section diameter.

28. The fastener of claim **26** wherein the breakneck diameter is approximately 85% of said first shank section diameter.

29. The fastener of claim **12** wherein said abutment face in said normal condition is a generally conical top end wall of said sleeve head coaxial with said sleeve with said bore being at the narrow end of said conical portion and said abutment face in said installed condition is flattened to a substantially planar condition transverse to the sleeve axis.

30. The fastener of claim **28** wherein said sleeve head has a conical countersinkable undersurface connecting said top end wall to said sleeve.

31. The fastener of claim **31** wherein sleeve head is a round style head with a flat undersurface transverse to the sleeve axis and said top end face retains a domed configuration in said installed condition.

32. A pull-type blind fastener adapted for installation with either a single action or double action setting tool of the type having a nose adapted to engage and pull the pin of a fastener and an anvil on the nose for reactively engaging the sleeve of the fastener thereby to apply a relative pulling force between the pin and thus set the fastener in a workpiece, said fastener comprising:

a tubular sleeve having a sleeve bore of continuous inner diameter between a blind-side end and a sleeve head formed on its opposite end, and an intermediate selectively annealed section on said sleeve;

a pin having a pin shank axially displaceable through said sleeve bore but locked against such displacement towards said head by a pin head abutting against said blind-side sleeve end, said pin shank including a smooth ungrooved first pin shank section adjacent said head and having a diameter substantially equal to said continuous sleeve bore diameter, a second pin shank section of slightly reduced diameter relative to said first section and

extending through a bore in said sleeve head a plurality of pull grooves defined between radial lands on said second pin shank section exteriorly to said sleeve head, a breakneck between said first and second sections, and a single stop shoulder at the end of said first section adjacent said breakneck that of said radial lands having a diameter substantially equal said stop shoulder;

said sleeve head including an outer abutment engageable by the anvil of the setting tool and deformable by the reactive engagement of the setting tool anvil from a normal condition wherein said bore has a normal diameter greater than said stop shoulder and admitting passage of said stop shoulder and radial lands to an installed condition wherein the diameter of said bore is reduced so as to engage said stop shoulder and thereby stop axial displacement of said pin through said sleeve with said breakneck in flush breaking alignment with said sleeve head, the pin portion remaining within said sleeve after installation having a continuous diameter substantially equal to the sleeve inside diameter.

33. A pull-type blind fastener adapted to secure a plurality of workpieces from one side of the workpieces and characterized by a tubular sleeve having a blind-side end and a rivet head formed at its opposite end and a pin extending axially slidably through said sleeve, the fastener being installed in aligned openings in said workpieces by applying axial pulling force to the pin and a reaction force against the rivet head sufficient to pull the pin through the sleeve and axially collapse the sleeve to form a retaining bulb on the blind-side of the workpieces, the improvement comprising:

means locking said pin to said blind-side end of said sleeve against axial displacement towards said rivet head, said pin having a first stem section of first diameter adjacent said blind-side end and a second stem section of second reduced diameter extending through an aperture in said rivet head and terminating exteriorly of said sleeve, a plurality of pull grooves on said exterior stem portion, a break groove of a third diameter lesser than said second diameter between said first and second stem sections, said first stem section terminating in a stop shoulder at said groove;

said rivet head bore having a normal diameter sufficient to admit passage of said pull grooves such that said pin may be inserted into said sleeve and through the rivet head from said blind-side end, said rivet head being deformable by said same reaction force and prior to formation of said bulb to an installed condition of reduced bore aperture wherein the rivet head stops axial movement of said pin through said sleeve at said stop shoulder with said break groove in predetermined relationship with said rivet head, whereby said second stem section can be broken off said pin at said groove leaving said first section terminating substantially flush with said rivet head.

* * * * *